Annual Report for Fiscal Year Ended 30 June 1966

CHIEF OF ENGINEERS CIVIL WORKS ACTIVITIES

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

REPORT PERTAINING TO RIVERS AND HARBORS, FLOOD CONTROL, BEACH EROSION CONTROL AND RELATED PURPOSES

VOL-1 OF TWO

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ANNUAL REPORT, DEPARTMENT OF THE ARMY

Fiscal Year Ended June 30, 1966

ANNUAL REPORT OF THE CHIEF OF ENGINEERS

U.S. ARMY

ON CIVIL WORKS ACTIVITIES

1966

IN TWO VOLUMES

Vol. 1

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Volume 1

Volume 2

Reports on individual project operations and related Civil Works activities published as a separate volume. For sale by Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Statistics on Waterborne Commerce of the United States are printed separately. (See ch. IX, sec. 10.)

SUBJECT: Annual Report on U.S. Army Civil Works Activities for Fiscal Year 1966

TO: THE SECRETARY OF THE ARMY

1. Transmitted herewith is my annual report on the Civil Works activities of the Department of the Army, as carried out by the Corps of Engineers in fiscal year 1966. Volume 1 of this report reviews the overall program status, accomplishments, and planning to meet existing and future needs, and presents summary data on water resources development by the Corps. Volume 2 contains detailed information on individual Civil Works projects and activities. Detailed data on U.S. waterborne commerce are published separately.

2. Civil Works activities of the Corps of Engineers involve a nationwide water resource development program which includes the planning, design, construction, operation, and maintenance of works for navigation, beach erosion control, flood control, hurricane protection, hydropower, water supply, water quality control, recreation, fish and wildlife preservation, and related purposes, as authorized by law.

3. The active Civil Works program consists of 4,300 project authorizations with a total estimated Federal cost of $29 billion. Appropriations for new work under this program have totaled $14 billion. Some $15 billion will be required to complete the active authorized improvements at 1,300 projects. Appropriations for Civil Works activities this fiscal year total $1¼ billion, of which $1 billion (80 percent) was for new work.

4. This program continues to provide large and widespread benefits to the Nation. Items of major importance are—

a. Navigation, calendar year 1965. Total U. S. waterborne traffic established a new record for the third consecutive year. Over 1¼ billion tons was distributed among coastal harbors and channels, Great Lakes harbors and channels, and inland and intracoastal waterways in proportions of 46, 17, and 37 percent, respectively. A total of 262 billion ton-miles of frieght carried on the Great Lakes and on the inland and intracoastal waterways also established a new record. This total was composed of 110

billion ton-miles on the Great Lakes, the largest movement since 1957, and 152 billion ton-miles on the inland and intracoastal waterways system, a new alltime high.

b. Flood control. In fiscal year 1966 the Nation suffered a series of extremely damaging floods, notably the flooding caused by Hurricane Betsy in September 1965. Hurricane Betsy, after crossing southern Florida headed across the Gulf of Mexico and struck Louisana and Mississippi. There was considerable shore damage on the Florida east coast, catastrophic damage in Louisiana, and appreciable damage in southernwestern Mississippi. In the fall and early winter, unusually heavy rains caused flooding at scattered locations in the Southwestern States. In February prolonged flooding occurred on the upper Mississippi River due to an extensive ice jam. During April and May heavy rainfall in eastern Kansas and western Missouri caused severe flooding in the lower Kansas River Basin and on the main stem of the Missouri River below Kansas City. As illustrated by these and other floods during the year, the provision of an adequate degree of flood protection remains one of the most pressing aspects of the Nation's water resource development program. Damages prevented by flood control projects in operation are estimated to total $622 million this fiscal year, clearly demonstrating the value of such works in reducing the drain on the Nation's economy as a result of flooding. There is a continuing recognition that protective works for flood control must be complemented with zoning controls and other regulatory measures to assure proper management of flood plain use. Under its flood plain formation studies program, the Corps is responding to increasing numbers of requests from States and local communities for advice in this regard.

c. Hydropower. Installed capacity approached the 9½ million kilowatt mark, the energy generated in fiscal year 1966 amounting to 42.5 billion net kilowatt-hours. These figures represent over one-fith of the Nation's total hydropower capacity and generation, and 4 percent of its total electric power capacity and generation. The cumulative total energy generated at Corps projects through fiscal year 1966 amounted to about 398.5 billion kilowatt-hours.

d. Water supply. The Corps provides 4.4 million acre-feet of storage for water supply in 44 reservoirs, which supplements the water supply for more than 2 million people in about 100 cities, towns, and rural areas. A dependable supply estimated at more than 3 billion gallons per day is available from storage now in operation. Some 5½ million acre-feet of storage space is being utilized, either exclusively for irrigation or jointly for that and

other purposes. Large quantities of water made available by power releases and evacuation of flood control storage also increase the quantity and improve the quality of downstream flows.

e. Public recreation use. Navigation projects and reservoirs furnish excellent opportunities for public outdoor recreation. Attendance at reservoir projects reached 168 million in calendar year 1965, an increase of 7 percent over the preceding year.

5. During this fiscal year the Corps of Engineers continued, at an accelerated pace, its Civil Works program for conserving, developing, and putting to better use the Nation's water resources in support of economic growth and human welfare. While we are faced with difficult technical, fiscal, administrative, and other problems, I consider that this year marks a period of solid achievement. Further, I feel that the widespread public attention being given to the urgent need for comprehensive planning and development of our water and related resources, together with the increasingly cooperative efforts at all levels of Government, and of other interested individuals and local organizations, is providing a sound basis for further substantial progress in future years.

WILLIAM F. CASSIDY
Lieutenant General, USA
Chief of Engineers

Highlights—Corps of Engineers Water Resources Development

Item	1966	1965	1964	1963	1962	1961	1960	1959	1958	1957	Cumulative trough 1966
	Fiscal years, except as noted otherwise										
I. APPROPRIATIONS[1] ($ MILLIONS):											
A. New work:[2]											
1. Navigation[3]	306	274	216	204	204	211	209	190	141	135	4,387
2. Flood control	419	453	387	353	325	286	286	278	226	212	5,907
(a. Flood control, Mississippi River and tributaries)[4]	(57)	(52)	(54)	(53)	(55)	(55)	(52)	(52)	(44)	(47)	(1,456)
3. Multiple-purpose incl. power	323	266	259	266	237	258	215	190	126	157	4,774
4. Beach erosion control	3	3	1	2	1	1	1	1	--------	1	18
Subtotal, new work	1,051	996	863	825	767	756	711	659	493	505	15,086
B. Other work[5]	279	258	234	221	208	180	162	157	146	134	4,565
Total (A + B)	1,330	1,254	1,097	1,046	975	936	873	816	639	639	19,651
II. NAVIGATION, FOREIGN AND DOMESTIC (calendar year):[6]											
A. Commerce (billions of ton-miles):											
1. Coastal (foreign and domestic deep-draft)[7]		326	334	337	338	330	([8])	([8])	([8])	([8])	
2. Great Lakes		109	106	95	90	87					
3. Inland and intra-coastal waterways		112	104	96	92	86					
Total (Rounded)		547	544	528	520	503					
B. Traffic (millions of tons):											
1. Coastal harbors and channels (foreign and domestic deep-draft)		589	573	553	533	501	512	496	477	519	
2. Great Lakes harbors and channels		217	213	195	183	177	196	172	164	225	

See footnotes at end of table.

Item	*Fiscal years, except as noted otherwise*										*Cumulative through 1966*
	1966	*1965*	*1964*	*1963*	*1962*	*1961*	*1960*	*1959*	*1958*	*1957*	
3. Inland and intra-coastal waterways		467	452	425	412	383	390	383	360	384	
Total (Rounded)		1,272	1,237	1,172	1,128	1,061	1,099	1,051	1,002	1,129	
III. FLOOD DAMAGES PREVENTED ($ billions) (cumulative)	14.6	14.0	12.5	11.8	11.3	10.6	9.7	9.2	9.0	8.7	
IV. POWER:											
A. Installed (millions of kw) (cumulative.	9.4	9.0	8.5	8.2	7.5	6.9	6.6	6.1	5.6	4.8	
B. Generated (billions of kwh)	42.5	38.0	33.3	30.0	29.9	27.2	27.9	26.8	27.2	22.6	
V. RESERVOIR STORAGE (million acre-feet):											
A. All purposes	207	196	184	176	169	164	162	155	153	150	
B. Flood control (maximum)	85	79	75	72	(9)	(9)	(9)	(9)	(9)	(9)	
C. Water supply	4.4	4.1	2.3	1.6	1.5	1.5	1.5	1.5	1.2	1.0	
D. Irrigation	5.5	5.5	5.5	5.0	4.8	4.0	4.0	4.0	4.0	4.0	
VI. PUBLIC ATTENDANCE AT RESERVOIRS (millions) (calendar year)	194	168	156	147	127	120	109	107	95	85	

See footnotes at end of table.

[1] Includes about $500 million expended on deferred-for-restudy, inactive, abandoned, or superseded projects.

[2] Advance engineering and design, and construction.

[3] Includes alternation of bridges obstructive to navigation.

[4] Included in 2.

[5] Operation and maintenance, surveys, administration, and miscellaneous.

[6] Excludes tons and ton-miles moved (a) within Puerto Rico and (b) within Virgin Islands.

[7] Includes (a) ton-miles of carriage on the sea and on inland waters in domestic coastwise and intercoastal commerce and (b) ton-miles of foreign commerce on inland waters only.

[8] Not compiled on this basis prior to 1961.

[9] Not available.

CHAPTER I

THE CIVIL WORKS PROGRAM

1. THE SCOPE AND ORIGIN OF THE CIVIL WORKS PROGRAM

The Civil Works Program of the Corps of Engineers constitutes a major component of the vast aggregate of activities—Federal, State, local and private—through which the Nation develops, utilizes and conserves its water and related resources. Through the Civil Works Program the Federal Government: Provides the Nation's harbors and commercial waterways; constructs reservoirs, levees, channel improvements, and other works to protect cities and the larger agricultural valleys from floods; provides major outlets for drainage systems; installs works for shore protection; and constructs major multiple-purpose reservoirs which, in addition to providing flood protection, enable the generation of hydroelectric power, furnish water for municipal, industrial, and agricultural use, and regulate the major rivers to improve water quality, preserve and improve the fish and wildlife resource, enhance recreational potentials, and otherwise increase their value to the Nation. The reservoirs and waterways constructed under the Civil Works Program also have great value for recreation: In fact that program presently serves more recreationists than any other program of the Federal Government. In brief, the Civil Works Program provides for comprehensive development, utilization and conservation of the water resources of the United States for a multiplicity of purposes.

The rivers and harbors segment of the Civil Works Program had its beginnings in 1824 when the Corps of Engineers received a small sum to begin the improvement of the Mississippi and Ohio Rivers. It was not until 1917 that the program was expanded to encompass flood control, and then only for the Mississippi and Sacramento Rivers. In 1936 the Congress enacted the first general flood control legislation, and made the Corps responsible for the engineering features of a nationwide program for reducing flood damages. During the subsequent three decades the Civil Works

Program was gradually broadened until today it encompasses all of the activities previously mentioned.

With the growth of Federal activities in the water field, continuing efforts were made to improve cooperation and coordination between the various Federal agencies, and between those agencies and the States. Interagency committees were established at both field and Washington levels and use was made of interstate compact commissions, study commissions, and other devices. In 1965 a long stride forward was made by the enactment of the Water Resources Planning Act and the establishment of the Water Resources Council under that act. This act also authorized the establishment of Federal-State River Basin Commissions to coordinate the planning and carrying out of water resource development plans within major basins, or regions. The Department of the Army is represented on the council and the Corps plays a leading role in the preparation of the comprehensive plans called for by the act. The effect of these recent developments is to make the Civil Works Program an integral part of a much broader national program encompassing not only all of the Federal water activities, but also those of the States and their subdivisions. Such a comprehensive and coordinated program has been a goal of many national leaders since the turn of the century. Now that this goal has been largely attained it may be expected that little will be heard of the charges, so often made in the past, that Federal programs in the resources field are piecemeal, uncoordinated, and wasteful.

An outstanding characteristic of the Civil Works Program has been its adaptability to the changing needs of the Nation. It is expected that it will continue to change in the future. In its monumental 1961 report the Senate Select Committee on National Water Resources predicted that the rapid industrialization and urbanization of the United States will make the regulation of the rivers for all purposes an increasingly important goal of its water resource development programs. The Civil Works Program is gradually being adjusted to meet this, and other foreseeable future needs.

2. ORGANIZATION

The Civil Works Program is administered by the Chief of Engineers under the general supervision of the Secretary of the Army. The line of responsibility runs from the Chief of Engine-

ers through the Director of Civil Works and the Division Engineers to the District Engineers. There are 11 Division Engineers and 38 District Engineers. Each District Engineer administers the program within a District composed, in general, of a river basin or group of river basins. A Division is usually composed of several Districts. A list of the Divisions and Districts will be found in Appendix E. 1.

The Division and District Engineers are also responsible for the Military Construction Program of the Corps of Engineers.

CHAPTER II

SUMMARY OF ACCOMPLISHMENTS—FISCAL YEAR 1966

Water resources projects now in operation have reduced transportation costs, shore erosion, and flood and hurricane damages, provided electric energy, improved water supplies and recreation, and preserved and enhanced fish, wildlife, and other natural values.

1. NAVIGATION

The navigation element consists of three major parts: foreign and coastwise traffic at coastal harbors and channels; foreign and lakewise traffic at Great Lakes harbors and channels; and traffic limited to the inland and intracoastal waterways. Each of these three systems has more than justified construction and operating costs by savings in transportation costs. In calendar year 1965, the waterborne commerce of the United States amounted to 1,273 million tons, consisting of 588 million tons of foreign and coastwise traffic at coastal harbors and channels, 211 million tons of foreign and lakewise traffic at Great Lakes harbors and channels, and 474 million tons of inland traffic on the inland and intracoastal waterways. The total ton-miles of freight carried on the Great Lakes, inland, and intracoastal waterways amounted to 262.4 billion, of which 110.0 billion moved on the Great Lakes system, and 152.4 billion were carried on the inland and intracoastal system. (An analysis of the navigation program is shown in ch. III, vol. 1 of the 1955 Annual Report.)

Coastal harbors and channels. Natural harbors and channels are being progressively improved to provide the greater depths required for modern ocean carriers. Depths of 35 feet now generally prevail at major harbors on the Atlantic and gulf coasts, ranging up to 45 feet in New York Harbor. Depths of 30 to 40 feet are generally available along the Pacific coast. Harbors and channels of lesser depth also have been provided for commercial fishing, recreational boating, and harbors of refuge.

Great Lakes harbors and channels. The vast water areas of the Great Lakes, joined by improved connecting channels, provide a low-cost transport artery that permits movement of materials and products in huge quantities to advantageously located industrial areas. Controlling depths in the connecting channels are now 27 feet or more in both upbound and downbound channels. There are some 60 harbors on the Great Lakes with authorized project depths of 18 to 27 feet. The Great Lakes are connected with the Gulf of Mexico by means of 9 - to 12 - foot barge navigation on the Illinois Waterway and Mississippi River. Connections with the Atlantic Ocean are provided by the New York State barge canal system and Hudson River, and by the 27 - foot St. Lawrence Seaway.

Inland and intracoastal waterways. The Federal government has improved in varying degree some 22,000 miles of inland and intracoastal waterways, of which about 19,000 miles are currently in commercial use. Commerce on these waterways increased nearly 6 percent during the past year to establish a new record of 152.4 billion ton-miles.

2. FLOOD CONTROL

Major Federal participation in flood control began in 1928 when Congress adopted the present project for the Mississippi River and tributaries. Primary Federal responsibility for nationwide flood control was assigned to the Corps of Engineers by the 1936 Flood Control Act, which also established the basic Federal policy for that activity.

The authorized flood control program, including the Mississippi River and tributaries project, is estimated to cost $11.4 billion. Since 1936, the Corps of Engineers has completed about 580 specifically authorized projects having a cost of about $2.8 billion. Projects having an estimated cost of about $5.5 billion are under construction, and many of these have ben advanced to the point where they are at least partially effective for flood control. The remainder of the active flood control program, estimated to cost $3.1 billion, has not been started. Many multiple-purpose reservoir projects with power provide important flood control benefits. As shown in appendix B, 898 Corps of Engineers projects of all categories are now fully or partially effective for flood control and, during the limited period they have been in operation, these projects have prevented about $14.6 billion of flood damages.

However, the results of this program also indicate that, despite the huge investment already made in flood control works, many communities remain vulnerable to major flood catastrophes, and average annual flood damages continue to constitute a costly drain on our Nation's assets. With the progressively more intense occupancy and development of flood plains, there is now a growing realization that the Nation's flood problems cannot be effectively and economically solved by endless provision of more numerous and ever-larger flood protection works; and that better management of flood plain use, through regulatory controls, must be undertaken by the local authorities concerned. In adopting such programs, local interests are turning to the Corps of Engineers for technical advice and assistance, which are being furnished under its program of flood plain information studies (See para. 6, ch. III.)

3. HYDROELECTRIC POWER

Electric power development in the program has grown with the increasing needs of the Nation for electric energy and the expanding Federal interest in its development and use. The construction of reservoirs has provided fine possibilities for the development of waterpower. Power production during the fiscal year amounted to 42.5 billion net kilowatt-hours of electric energy, or about 22 percent of the hydroenergy and 4 percent of the electrical energy generated in the Nation. The total enegry generated at Corps projects through June 30, 1966, amounted to about 398.5 billion kilowatt-hours. As of June 30, 1966, installed capacity was almost 9½ million kilowatts, or about 21 percent of the hydro capacity and 4 percent of the total electrical capacity of the Nation.

4. WATER SUPPLY

Domestic and industrial. About 4.4 million acre-feet of water supply storage space in 44 reservoirs supplements the water supplies for over 2 million people in about 100 cities, towns, and rural areas. This storage provides the main water source for several communities. A dependable supply in excess of 3 billion gallons per day is available from storage space now in operation. There will be about 2.4 million acre-feet of additional domestic

and industrial water supply storage in 23 reservoirs under construction.

Low-flow improvement. Release of stored floodwaters for navigation, power generation, water quality control, and other useful purposes during normal low-water periods not only increase the quantities but also improve the quality of downstream flows, benefiting water supplies, recreation, fish and wildlife, and other values downstream. Provision is being made for the inclusion of nearly 690,000 acre-feet of water quality control storage in 12 projects under construction.

Irrigation. About 5.5 million acre-feet of storage is being utilized either exclusively for irrigation or jointly for irrigation and other purposes. Reservoirs under construction will provide almost 375,000 acre-feet of additional joint-use storage for irrigation and other purposes.

5. PUBLIC RECREATION USE

The Corps in the development of its water resources program has contributed to the Nation's outdoor recreational opportunities by creating vast expanses of water areas and many miles of shoreline. Since water is a prime factor in many recreation activities, these resources provide for the American people an enormous potential for outdoor recreational pursuits.

Public-use visitation at reservoirs and certain waterway projects reported for calendar year 1965 increased to 168.6 million, a significant contrast to the 16 million annual attendance in 1950. Our expanding population with more leisure time, more purchasing power, and more mobility continues to seek more opportunities to enjoy outdoor recreation. The new artificial lakes created through the construction of reservoirs afford the American people such opportunities. This is evidenced by the peak-day attendance of 4,122,000 persons using the facilities and 209,800 watercraft in operation in these waters. In almost all cases, peak attendance occurs during the summer months, although in parts of the country such as the Southeast, Gulf, and Southwest areas, and even to some extent in colder areas, recreation use is on a year-round basis.

Recreational craft are also operating extensively on more than 20,000 miles of inland waterways that were once used primarily for commercial navigation. Over 250 small boat harbors have

been developed with Federal assistance on the coasts, Great Lakes, and inland waterways.

Recreation has become so extensive a use of water resource projects that it can now be considered a factor in the economic justification for construction of multiple-purpose dams and reservoirs.

The general policy followed in the past with respect to the installation of recreation facilities has been that the Federal government supply the basic requirements for public health and safety, such as access roads, parking areas, water wells, sanitary facilities, boat launching ramps, camping areas, and picnicking facilities. As a cooperative venture many of the States, counties, cities, and communities actively participate in the funding, construction, and maintenance of public-use facilities at Corps projects.

Uniform policies with respect to recreation and fish and wildlife benefits and costs of Federal multipurpose water resource projects have been set out in the Federal Water Project Recreation Act (Public Law 89–72) to guide the cost sharing of recreation facilities thus encouraging greater non-Federal participation.

The non-Federal interests have been further encouraged by the Land and Water Conservation Fund Act of 1965 (Public Law 88–578) which established a land and water conservation fund to assist the States and Federal agencies in meeting the outdoor recreation demand.

Certain facilities and the necessary services are also provided on a commercial basis by concessionaries who engage in the rental and care of boats, and provision of food and overnight accommodations. In addition, quasi-public agencies are authorized to develop certain project areas, and many youth camps are sponsored by such agencies. About 240 of these camps are established on Corps reservoirs having lands available for such use.

Recreation facilities and use at civil works projects as reported for calendar year 1965:

Major reservoir access areas	2,820
Public launching lanes	4,160
Picnic areas	2,190
Swimming beaches	590
Rental units and camping spaces	35,920
Organized camps	240
Rental boats operating in project area	17,700
Pounds of sport fish reported caught in project waters	35,760,000

In order to provide for the record increase in family camping, additional camp spaces are constantly being made available. A great variety of camping equipment from station wagons to modern travel trailers permit families to enjoy the many activities available at Corps land and water areas.

There are many outstanding public-use developments at the more than 300 water resources projects under the Corps program with the attendance running over one million at 47 projects.

Ten highest attended projects

Denison Dam (Lake Texoma), Red River, Okla. & Tex.	8,905,000
Buford Dam (Lake Sidney Lanier), Chattahoochee River, Ga.	5,524,000
Old Hickory lock & dam, Cumberland River, Tenn. & Ky.	4,903,000
Ferrells Bridge Dam (Lake O' the Pines), Cypress Creek, Tex.	4,336,000
Clark Hill Reservoir, Savannah River, S.C. & Ga.	4,264,000
Lake Cumberland (Wolf Creek Dam), Cumberland River, Ky.	3,840,000
Allatoona Reservoir, Etowah River, Ga.	3,399,000
Table Rock Reservoir, White River, Mo. & Ark.	3,332,000
Whitney Reservoir, Brazos River, Tex.	3,130,000
Hartwell Reservoir, Savannah River, Ga. & S.C.	3,093,000

6. FISH AND WILDLIFE

Hunting opportunities at Corps projects vary greatly from project to project. Many areas are open to quail, pheasant, and rabbit hunting, while at others there is deer hunting. Probably the largest number of hunters come for duck and geese. Areas which are intensively used for general recreation are closed to hunting. Certain Federal and State refuges located at these projects are closed to hunting.

The many miles of shore and trail offer plenty of opportunity to those interested in nature studies. Fishing opportunities are available for both the skilled and unskilled fisherman at most reservoir projects.

7. CONTRIBUTIONS TO AMERICAN BEAUTY PROGRAM

Natural beauty is now recognized as a natural resource which requires protection and when disturbed by man it needs enhancement by processes of rehabilitation and sound management techniques. Increased emphasis on appearance and setting of civil works projects are now considered together with the functional and utilitarian features. The major project structures and related elements such as roads, visitor areas, and other elements which

surround the projects are planned to be aesthetic assets to the region and the Nation.

Land is being acquired at reservoir projects to permit the retention or development of wooded waterside areas for recreational use. At Blanchard Reservoir, Pa., much of nearby Bald Eagle Mountain was purchased under sound real estate practices. This was found to be as economical as acquiring the real estate required specifically for project purposes and then paying severance damages on the remainder. These practices, not justified on the basis of beautification, will nevertheless contribute greatly to the project's scenic values.

Flood control reservoirs—manmade lakes—are things of beauty in themselves. The reservoirs present and enhance natural beauty and create vast outdoor recreation resources to meet the rising public need for recreation facilities. Since June of 1965 more than 40,000 trees and shrubs and nearly 500,000 seedlings have been planted at 45 Corps reservoirs in the Southwestern Division. During the same period in the Missouri River Division 379,700 trees, shrubs, and seedlings were planted at 13 reservoirs. This, together with plantings of previous years, now total 1,366,800 plants. Scenic enhancement and shelter belt benefits are the primary objectives of these plantings in the plains area. At the new Beltzville Dam and Reservoir under construction in Pennsylvania, landscape planting plans for highway relocations have been developed to serve both practical and aesthetic purposes.

Not only are the projects contributing to the beauty of the immediate surroundings, silt is trapped, streams below dams are cleaner, flow is regulated to minimize the fluctuations that otherwise might leave ugly muddy shallows in the hot months when people generally seek recreation on the rivers. Flood control projects have brought about transformations in the appearance and value of the protected downstream flood plain. On the Missouri River, when channel cutoffs are built to eliminate sharp bends, the resulting oxbow are being stabilized and developed for public recreational use.

Special attention is being given to the aesthetic aspects in plans currently under development of such things as minimizing or alleviating construction scars; screening unsightly areas, storage areas, and utility buildings by means of trees and shrubs; and designing structures to harmonize architecturally with the environment. An outstanding example of the latter is Libby Dam project, now under construction in Montana. In designing the

project, the architect blended major portions of the huge dam structure into the surrounding environment to be harmonious and, as much as possible, compatible with the rugged beauty of the wilderness site.

Navigation pools of canalized waterways and their lock structures contribute to the enjoyment of many admirers of water development complexes. An attractive landscaped visitor's information building has been built for the Soo locks, Michigan.

The forces of nature and the encroachments of man sometimes combine to deplete or destroy one of the Nation's greatest sources of beauty, recreation, and inspiration—the coastlines and beaches of the seas and the Great Lakes. Federal activities for the control of beach erosion and hurricane flooding are entrusted to the Corps of Engineers. The Corps makes technical studies of sea and shore phenomena required to devise effective beach programs and recommends projects in which a share of the cost is borne by the Federal government to prevent destruction of scenic and recreation values by storm.

8. POLLUTION ABATEMENT

In accordance with procedures prescribed in Executive Order 11258, dated November 17, 1965, "Prevention, Control and Abatement of Water Pollution by Federal Activities," the Director of the Bureau of the Budget was furnished a phased and orderly plan for water pollution control at Corps of Engineer installations. The plan for civil works projects covers measures at some 100 water resource projects and activities at an estimated cost of nearly $9 million.

The major pollution problem facing the Corps is the disposal of sanitary and industrial wastes dredged from channels and harbors, particularly on the Great Lakes. Dredging operations do not result in the introduction of any new form of pollution to the Nation's waterways. In areas where material to be dredged has already been polluted by industrial or sanitary waste material and is in a quiescent state, the removal of this material to another area for disposal does create pollution in areas where it did not previously exist. This problem being most acute in the Great Lakes area, a preliminary plan was prepared in fiscal year 1966 for confining such dredged spoil at the most polluted Great Lakes harbors. Studies to determine the extent of this problem Corps-wide have been initiated.

CHAPTER III

PLANNING

The planning activity of the Corps of Engineers provides the foundation for the Civil Works Program. Basically it involves the determination of immediate and long-term water resource development needs together with formulation of a sound design for meeting those needs in an orderly, efficient, and timely manner within the constraints and controls which have evolved over a period of mnay years on the basis of Congressional actions on matters of this nature. Included are studies ranging from consideration of a relatively local navigation, flool control, or beach erosion control improvement to consideration of a comprehensive plan of development of all water and related land resources of a major river basin involving improvements under the programs of other Federal agencies coordinated through the Water Resources Council. Good planning provides for avoidance of wastefulness of over utilization of resources in point of time, location, and amount, and the detriment to progress attendant upon underutilization with respect to the same indices. Our water and related land resources must serve an array of domestic, municipal, industrial, agricultural and other human activities ranging from the siting of homes to satisfaction of aesthetic needs. Where conflicts exist, they must be resolved by reasoned choice.

1. COMPREHENSIVE STUDIES

a. Interagency studies of water and related land resources. The Water Resources Council, created in 1965 by Public Law 89–80, assumed the sponsorship of the Coordinated Comprehensive River Basin Planning Study Program previously sponsored by an ad hoc interagency council. The Department of the Army, acting through the Corps of Engineers, actively participates in that coordinated interagency study program. The first funds for this program were made available in fiscal year 1963 on the basis of coordinated interagency budgets for studies in the program. During the fiscal year the Corps was participating in 21 of these

studies. Funds of $6,487,000, apropriated for this purpose in fiscal year 1966, were made available to Corps offices to continue these studies.

b. *Northeastern United States water supply study.* In accordance with section 101, Public Law 89–298, the Corps of Engineers is authorized to make a study of the metropolitan water supply problems of Northeastern United States and the major facilities required to solve these problems. The recent drought conditions in the study area indicate the seriousness of these problems and the Corps is preparing for early initiation of the study.

c. *Comprehensive Water Resources Survey for Appalachia.* Pursuant to section 206 of the Appalachian Regional Development Act, Public Law 89–4, the Corps of Engineers, in cooperation with other Federal and State agencies and the Appalachian Regional Commission, is preparing a comprehensive plan for the development of the water and related land resources of the Appalachian Region, which plan is to constitute an integral and harmonious component of the regional economic development program authorized by the act.

The study authority establishes new dimensions for water resources planning in that it requires that special attention be given to formulation of water resources projects in coordination with other economic development programs in such manner as to stimulate economic growth of a large region of the country. New procedures for measuring the economic impacts of water resources projects are being devised as a part of this study. This study is being conducted by the Corps Office of Appalachian Studies at Cincinnati, Ohio. Twelve Corps Districts in four Divisions and concerned Federal and State agencies are participating in the study of this area which encompasses parts of 11 States and all of West Virginia. The study is well advanced and is scheduled for completion for submission to Congress by the President by December 31, 1968.

2. INVESTIGATIONS AND REPORTS

Specific projects and systems of projects for development of water and related land resources are investigated for engineering and economic feasibility in studies and investigations specifically directed by the Congress.

During the fiscal year the Public Works Committees of Congress adopted 88 resolutions requesting review of previous reports on

proposed river and harbor, flood control, and related improvements. In addition, 51 studies were authorized by the River and Harbor and Flood Control Act of 1965.

At the beginning of the fiscal year about 1,150 investgations were outstanding in the field offices of the Corps. The status of reports processed during the year is summarized below:

Reports transmitted to—	*Number*
Congress	100
Bureau of the Budget	106
State and Federal Agencies	81
Office of the Chief of Engineers	114
Total actions	401

3. REVIEW BY BOARD OF ENGINEERS FOR RIVERS AND HARBORS

One of the duties of the Board as specified by law is to conduct an independent review and make recommendations to the Chief of Engineers concerning reports prepared by various Corps offices as to the advisability of water resource development improvements. As a part of the planning process the Board held six meetings of 1 to 3 days duration in Washington. The Board considered 121 reports, acted favorably on 43, unfavorably on 59, deferred action on 7, and returned 12 to the reporting officers for further consideration. The Board recommended construction of projects totaling $982,616,300, of which $527,105,200 was estimated U.S. cost and $455,511,100 the cost to local interests for work and cash contributions.

4. PROJECT AUTHORIZATION

The River and Harbor and Flood Control Act of 1965 authorized 150 Corps projects or project modifications having an estimated Federal cost of $1,985,785,000. This includes 91 flood control or multiple-purpose projects at a cost of $1,635,766,000; 50 navigation projects at a cost of $343,338,000; and 9 beach erosion control projects at a cost of $6,681,000.

5. ADVANCE ENGINEERING AND DESIGN

A backlog of projects ready for initiation of construction is in preparation to allow inclusion as the national budgetary policy

permits, at the same time assuring the development of a sound and well-balanced program consistent with the Nation's needs. This preparation includes firm cost estimates, construction schedules, and detail for coordination with local interests.

With $23,559,913 made available together with funds carried over from prior years, planning was prosecuted on 173 projects, consisting of 27 navigation, 137 flood control, 8 multiple-purpose projects, and one beach erosion control project. Planning on 57 of these projects was advanced to the stage where construction could be readily initiated. Funds of $2,781,572 representing about 81 percent of the total available, were obligated.

6. OTHER PLANNING MATTERS

a. Studies by the U.S. Fish and Wildlife Service. Funds were made available to the Fish and Wildlife Service for continuation of a study of the effects of Corps projects upon fish and wildlife resources and for enhancement of these resources, in accordance with the Fish and Wildlife Coordination Act, Public Law 85–624. A total of $310,000 was transferred to the Fish and Wildlife Service from appropriations for "General Investigations of the Corps of Engineers." Data from these studies and recommendations by the Service are incorporated in survey reports of the Corps submitted to Congress.

b. Flood Plain Information Studies. Section 206 of the Flood Control Act of 1960 (Public Law 86–645), as amended, authorized the Secretary of the Army through the Chief of Engineers to compile and disseminate information on flood hazards. The reports contain maps showing areas subject to flooding and depths that can be expected. Technical advice and guidance on planning the use of flood plains and on reducing flood damages are also available. The studies are made at the request of State and local governmental agencies. Such studies are made largely at Federal expense within the limits of appropriated funds. Local interests are encouraged to provide mapping, aerial photography, streamflow records, and similar relevant assistance and information and adopt plans that will insure the best use of flood plains. During fiscal year 1966, 33 studies were completed and 44 new studies initiated.

In 1967 the program will be expanded to include the furnishing of flood hazard data and guidance to other Federal agencies. In addition much more technical assistance and guidance will be

provided to States and communities.

c. International Boundary Waters. International boundary water studies, United States and Canada: Pursuant to the treaty of 1909 between the United States and Great Britain, the International Joint Commission was organized in 1911. In general, the Commission exercises jurisdiction over matters involving the use, obstruction, or diversion of boundary waters. When such matters are assigned by the respective governments to the Commission for investigation and/or resolution, they are generally designated as "References." The Corps continued participation as a member of the following boards estabished by the Commission.

International Pembina River Engineering Board was appointed in June 1962 to investigate and report upon what measures could be taken to develop the water resources of the Pembina River in North Dakota and Manitoba. The members appointed to the Board formerly served in a similar capacity on the International Souris-Red Rivers Engineering Board. The Board submitted its report, dated December 31, 1964, to the Commission. Later the Commission, with the Board in attendance, held public hearings in June 1965 in the Province of Manitoba and State of North Dakota to receive the views of all interests with respect to the information and conclusions in the Board's report. The Commission has the mater under advisement.

International St. Croix River Engineering Board was appointed in September 1955 to determine if further development of the water resources of the St. Croix would be practicable and in the public interest. After submission of the Board's report in September 1957 the Commission sent its report to the two governments on October 7, 1959. During the interim and at the request of the Commission, the Board has been conducting field surveys to determine the degree and extent of pollution in the river. In April 1965 the Commission requested the Board to review the application of the St. Croix Paper Co. (Georgia-Pacific Corp.) for permission to reconstruct a company-owned dam crossing the river between Vanceboro, Maine, and St. Croix, New Brunswick. On October 15, 1965, the Commission approved the application. The reconstruction of the dam at Vanceboro, Maine, is underway.

International Saint John River Engineering Board was appointed in October 1950 to determine if the waters of the Saint John River system could be more beneficially conserved and regulated. The Board's report was submitted to the Commission in

April 1953. It outlined several projects, the development of which would be practical and in the public interest. The Commission submitted its interim report to the two governments in April 1954. Since then the services of the Board have been retained to advise the Commission, keping the latter informed on any resource developments being undertaken or proposed by entities in either country.

International Champlain Waterway Board was appointed in October 1962 to examine and report upon the feasibility and economic advantages of improving or developing a waterway from the St. Lawrence River through Lake Champlain to the Hudson River at Albany, N.Y. The Board submitted its report dated June 30, 1965, to the Commission. In January 1966 the Board, at the request of the Commission, submitted a supplement to its report of June 30, 1965. On May 17 and 18, 1966, the Commission held final public hearings at St. Jean, Quebec, and Burlington, Vt. The Commission has the matter under advisement.

International Great Lakes Levels Board was appointed in December 1964 to act as principal advisor to the Commission and to organize the detailed technical studies required to determine if measures within the Great Lakes Basin to regulate further the levels of the Great Lakes would be practicable and in the public interest. The Board, in January 1965, appointed a Working Committee which started the required technical studies. The Commission, with Board and Working Committee representatives in attendance, held two meetings with the State and Provincial representatives in January and February 1965 and held a series of four public hearings in the United States and Canada in May 1965 to afford interested officials and individuals an opportunity to present their views concerning lake regulation. The Board is continuing its comprehensive investigation and is scheduled to submit its report to the Commission in October 1970.

International Boundary and Water Commission, United States and Mexico, was established pursuant to the Water Treaty of 1944 with Mexico, which deals with the utilization of waters of the Colorado and Tijuana Rivers and the Rio Grande. Falcon Dam on the Rio Grande, 130 miles upstream from Brownsville, Tex., was the lowermost and first to be built (completed in 1953) of the international storage dams provided for by the water treaty.

Note. Boards of Control established by the International Joint Commission, their composition and duties, are described in volume 2 under "Miscellaneous Civil Works, International Boundary Waters."

Amistad Dam, on the Rio Grande 290 river-miles upstream from Falcon Dam, is under construction.

Columbia River Treaty Permanent Engineering Board. Under provisions of the Columbia River Treaty of January 17, 1961, between the United States and Canada, the two governments announced the appointment of this four-man Engineering Board in December 1964. A representative of the Corps serves as Chairman of the U.S. Section of the Board. One of the functions of the Board is to keep the two governments informed as to the results being achieved and to assure that the Treaty objectives are being met.

d. Collection and Study of Basic Data. The collection and study of basic data are indispensable to the planning, design, and operation of river basin projects in development of the Nation's water resources. The major portion of this type of activity involving the Corps of Engineers is done by other Federal agencies under cooperative arrangements. The cooperative programs pertaining to the observation, compilation, and publication of data on streamflow, rainfall, and wildlife resources are carried on at the request of the Corps and are financed by transfer of funds. A description of these activities is presented below:

(1) *Cooperative programs with the U.S. Weather Bureau.*

(*a*) The Hydroclimatic Network of recording rainfall gages was operated by the U.S. Weather Bureau at the request of the Corps. Funds of $651,800 were transferred to the Weather Bureau by the Corps for continuation of the network in fiscal year 1966. These funds include costs for new digital-type rainfall gages to replace the reconnaissance-type gages that have been in operation for over 15 years. In addition, about $130,000 were obligated this fiscal year for the purchase of about 130 additional gages that had not been delivered by the end of the year. A total of 2,830 stations (2,382 recording) were in operation on June 30, 1966. The data are published by the Weather Bureau in "Hourly Precipitation Data" and "Climatological Data" issued monthly by States.

(*b*) The Hydrometeorological Branch of the Weather Bureau continued during the fiscal year to review meteorological aspects of the Corps storm study program and to prepare estimates of probable maximum precipitation for use in engineering design. Funds of $170,300 were made available to the Weather Bureau to finance this operation in fiscal year 1966. Accomplishments during the year include continuation of the study to provide

generalized charts of maximum probable precipitation for the Southwest States; development of meteorological parameters for several major hurricanes of record and standard project hurricanes for use in Corps coastal protection projects studies; preparation of probable maximum precipitation estimates and rainfall frequency studies for two proposed interocean canal routes in eastern Panama and northwest Columbia; estimates of probable maximum precipitation for four project areas; review and preparation of meteorological analysis of four storm studies; and other investigations and activities including presentation of lectures on hydro-meteorology at a conference in southeast Asia and training of foreign students in hydrometeorological methods.

(*c*) The River and Rainfall Reporting Networks currently totaling 38 were continued in cooperation with the U.S. Weather Bureau to provide timely reports of rainfall and river stages for flood forecasting in connection with the operation of Corps water resources projects. Funds of $171,200 were transferred to the Weather Bureau in fiscal year 1966 for this program.

(*2*) *Cooperative stream gaging program with the U.S. Geological Survey.* The U.S. Geological Survey continued the cooperative stream gaging program as required by the Corps. Funds of $2,332,000 were transferred to the Geological Survey at Washington level for construction and operation of about 2, 309 stations during the fiscal year. Data from these stations and others are published by the Geological Survey in a series of "Surface Water Records" issued annually for each State.

(*3*) *Corps of Engineers streamflow and rainfall data.* The Corps independently operates a limited number of rainfall and stream gaging stations for special purposes. Data from these stations are published by the Corps, the U.S. Geological Survey, the U.S. Weather Bureau, or are maintained in field office files. (See ch. III, sec. e, Research and Development, *Hydrologic Studies.*)

(*4*) *International water studies.* In order to carry out U.S. obligations under international agreements, several divisions and districts of the Corps having jurisdiction over areas bordering Canada, participated in a number of engineering and control boards functioning under the International Joint Commission. Funds of $85,000 appropriated for this purpose in fiscal year 1966 were made available to respective Corps offices to continue this important function.

e. Research and Development. The civil research program in-

cludes water resources research and oceanographic research activities. Principal research areas were—

Aquatic plant control.
Coastal engineering research.
Engineering studies.
Fisheries engineering investigations.
Great Lakes research.
Hydrologic studies.
Hydrometeorological studies.
International Hydrologic Decade.
Plan formulation and evaluation studies.

Total funding for civil research was approximately $5,199,000 for the fiscal year, of which $3,879,000 was applied to water resources research and $1,320,000 for oceanographic research. Technical progress and accomplishments in each of the principal areas are described herein.

The Corps was represented on review committees of the Federal Council for Science and Technology and participated in the annual examinations of water resources and oceanographic research programs to coordinate and strengthen the related programs of the Federal agencies.

Participation in information retrieval and research cataloging activities of the Science Information Exchange and the Department of Interior's Office of Water Resources Research has been continued by the Corps.

Aquatic plant control. As a part of the general aquatic plant control program in the southeastern United States and along the Gulf coast, the Corps is engaged in studies leading to more effective means for combating the spread of water-hyacinth, alligatorweed, and other obnoxious growths in the watercourses. In cooperation with the Departments of Agriculture, Interior, and Health, Education, and Welfare, State agencies, educational institutions, and private industries, the Corps is conducting field experiments on the aquatic plant control problem, including mechanical and chemical control methods. During 1966 work was continued in testing mechanical equipment and available chemicals with regard to their applicability and effect on aquatic plants, with followup tests on those showing a possibility of being suitable for aquatic plant control. Chemical controls producing good results in laboratory and small-scale tests were further tested under field conditions on a much broader scale. Even though some tests show good results in controlling alligatorweed, no conclusion can be

drawn as to a positive control. However, discovery of the effect of certain organic acids in promoting the effectiveness of some common herbicides gives good promise of developing a more useful and less hazardous herbicide for practical use in the control of alligatorweed. The Agricultural Research Service of the Department of Agriculture, through its work in South America on a biological control for alligatorweed, obtained clearance for introducing into the United States a beetle which is a specific parasite of this weed. The beetle was introduced in Georgia, Florida, and Mississippi. Results during the 1966 growing season are very promising. A second beetle is undergoing final tests and may be ready for release during 1967.

Coastal engineering research. During the fiscal year work was done on studies concerning the characteristics of ocean waves by actual measurement at a number of localities; sources of beach material; wave runup and overtopping on shore structures; propagation and effect of secondary waves; study of longshore currents; stability of rubblemound structures; relation of littoral drift rate to incident waves; amount of suspended sand in the surf zone; model scale effects; adaptations of the wave spectrum analyzes to laboratory and full field use; use of radioactive and fluorescent tracers in beach studies; beach deformation under wave action; use of offshore borrow material for beachfills; reexamination of completed shore protection projects; relation of edge waves and cusps; and breaker characteristics and wave setup. A major effort was involved in a geophysical and geological search for offshore bottom materials that would be suitable for beach use along the Atlantic Coast, and in a study of methods to get this material onshore.

Research to supplement staff activities was carried out at 10 universities under 13 contracts and with 2 commercial firms. Funds were also provided the Waterways Experiment Station to assist in construction of the generalized tidal model basins.

Engineering studies. Under this program, work on 75 research projects was conducted during the fiscal year. These projects cover seven fields of research which are studying improvements in procedures for the analysis of hydrologic and engineering data, refinement in design methods, and the development of better materials and practices to be utilized in the construction and maintenance of hydraulic structures.

The total program cost for the fiscal year was $1,445,918 of which about 74.1 percent was expended by the Waterways Ex-

periment Station, 8.1 percent by the Hydrologic Engineering Center, 5.1 percent by the Coastal Engineering Research Center, and the remainder by division and district offices.

Two engineering studies were completed during the year. In addition, eight substudies under continuing research projects were completed and twelve technical research documents were published to provide significant results for interim use prior to final completion of the entire investigation project.

(1) *Structural field.* Research was performed to improve the durability of paint applied to gates for locks and dams, penstocks, tunnel liners, scroll cases and other steel components exposed to severe hydraulic conditions; to establish through laboratory and field testing the suitability of waterstops and gate seals of various types of materials; to evaluate performance and to develop improvements in prestressed and reinforced concrete elements exposed to hydraulic environments; to develop methods and criteria for determination of true in-situ shear strength of weak foundation rock; and to improve design criteria for reinforced concrete structures constructed at civil works projects. During the year a new paint manual for use by designers and specification writers was prepared and various plastics used in waterstops and gate seals were evaluated. Through the Reinforced Concrete Research Council, the Corps participated in investigations at the Universities of California and Texas concerning shear strength of concrete beams and the effects of certain forces on slender concrete bridge piers such as are used in bridges across deep reservoirs.

(2) *Hydrology field.* The major portion of research in this field concerned studies to improve current methods and to develop new techniques and procedures in assembly, analysis, and application of hydrologic data. Electronic computer programs were being developed and tested at the Hydrologic Engineering Center as a means of simualting variable sequences of hydrologic events of variable magnitude; studies were continued at the Center pertaining to development of reliable and usable methods of establishing flood probabilities and low flow probabilities; and rainfall-runoff relationships were analyzed in Hawaii for use in developing hydrologic criteria for the Islands. New and improved hydrologic equipment was also being developed. Significant progress was achieved on the studies related to simulation of daily and monthly streamflows and on development of an automatic optimization procedure suitable for electronic computers. Sufficient data have

been observed at the streamflow and rainfall gages in Hawaii to permit the development of preliminary rainfall runoff relationships for two of the Islands.

(3) *Electrical and mechanical field.* Corrosion mitigation studies were made to develop criteria and techniques for protection of submerged or buried components of civil works projects. The current program of investigation of sheet piling in fresh water structures is nearing completion and a start was made on investigations of steel piling and prestressed concrete piling in salt water.

(4) *Soil mechanics field.* Research was done to develop more efficient and rational methods of embankment and foundation design. Information required concerning the strength and volume change characteristics of soils was obtained; new field and laboratory equipment and techniques were evaluated; and methods were developed for learning of impending embankment or foundation failure. Prototype reports and data sheets providing information concerning design assumptions, construction methods, and unusual problems and their solution were published. Field control data from all earth and rockfill dams under construction were collected and evaluated for effectiveness of criteria and its application to design and construction. The designers were given a more rational selection of design values for high dams through research on large specimen of crushed rock which shows that high pressures cause a breakdown of hard materials. A standard manual for soil sampling was in preparation. Studies of instrumentation for safety of dams during and following construction, including earthquake effects, were underway and progress was made on a manual on instrumentation for earth and rockfill dams.

(5) *Geology field.* Research effort was continued on the grouting of foundations and on the study of rock mechanics for dam foundations. The grouting studies were made to develop more effective and economic foundation consolidating grouts and grouting methods using existing and new chemical solutions. The rock mechanics research was made to develop better field and laboratory testing procedures for deriving and evaluating in place strengths of soft to medium hard rock foundations and to determine the influence of rock structure and pattern on the behavior of rock masses under various conditions of loading and rock strengthening. This research is providing better understanding of and design criteria for action of rock masses as part of structural systems (e.g. in dam foundations, in tunnels and in cut slopes for channels).

(6) *Concrete field.* Emphasis was placed on the study of cracking and of the durability of concrete. In addition, work was carried out to reduce the cost of concrete construction, to evaluate new processes of construction, and to develop and evaluate new laboratory techniques. The research on cracking of concrete includes study of techniques for producing and placing mass concrete free of tensile stresses which produce cracking, of volume stability, and of temperature rise and the control of the temperature gradient as the concrete cools. The durability of concrete under freezing conditions such as in navigation locks was investigated and the destructive interaction between cement and certain types of aggregate was studied. Economy in concrete construction may be effected by the studies made in reduction in quantity of cement used, in methods of lift surface cleanup, and in the curing of concrete. The new processes, materials and techniques evaluated include the use of adhesives for repairing structures, for joining precast elements or attaching other materials to concrete, and for coating surfaces for protection from erosion. Study was also made of the use of expanding cement to overcome drying shrinkage.

(7) *Hydraulics field.* Investigations in this field concern harbors and shore protection, dams and flood channels, navigation locks, and instrumentation. Studies were made of the shoaling processes, the effectiveness of various types of groins, jetties, and rubble-mound breakwaters, maintenance dredging techniques, shore protection by sand dune stabilization and growth by sand dune stabilization and growth by sand fences and vegetation, and shore protection by beach fill. The research on dam and flood channels establish improved and new design criteria for and verifying prototypes operation of spillways, outlet sluices, gates stilling basins, natural river channels, and high velocity flood control channels. Development tests of a longitudinal floor culvert system for 1,200-foot navigation locks were done. In the area of instrumentation, development of a water level indicator for prototype lock tests and a device for determining surface roughness for hydraulic structures was well underway.

Fisheries engineering investigations. A program of fisheries engineering research initiated in 1951 to determine the most efficient and economical design for structures and facilities for upstream and downstream passage of anadromous fish at dams in the Columbia River basin was continued. Current studies have been oriented primarily to problems in the passing of young fish moving downstream through turbines, and in collecting fish at

the upstream face of dams and guiding their movement into safe passageways.

Great Lakes Research. The recently expanded program of scientific data collection and research activity concerning the Great Lakes area, was continued. The expanded program is designed to support the Corps mission in the Great Lakes area by providing solutions to engineering problems encountered in planning the optimum comprehensive development and use of the water and related land resources in the area. The program ultimately will provide improved techniques for measuring and interpreting data as they apply to large bodies of water, improved techniques for forecasting supplies of water to the Great Lakes, and improved plans for regulating the levels and outflows of the lakes.

The results of the studies have already proven to be of value in the design and operation of Great Lakes facilities. For example, data on lake levels, channel and harbor depths and currents on the lakes benefit navigation interests by permitting optimum loading of vessels; information on water levels, interlake flows, surface and ground water flows permit maximum generation of power; knowledge of ice conditions benefit navigation, hydro-power production, and municipal and industrial development; and data on wave action, currents, shore and beach erosion and harbor silting result in major benefits by reduction of maintenance dredging costs.

The research program described above is being conducted by the Great Lakes Research Center which was formally established during the latter part of fiscal year 1966 as a major element of the U.S. Lake Survey District.

Hydrologic Studies. Under this program, field offices of the Corps of Engineers continued essential studies on storms, sedimentation, streamflow and rainfall data and general hydrologic problems. The results of these studies are utililzed by field offices for the optimum design, construction and operation of water control structures. Funds of $190,000 were appropriated for these hydrologic studies in fiscal year 1966.

Hydrometeorological Studies. These activities carried out by the Weather Bureau with funds made available by the Corps are described under "Collection and Study of Basic Data." Approximately one-half of these funds are applied to the development and refinement of general theoretical concepts relating to maximum precipitation criteria used for planning and design purposes. This

portion of the activity is considered to be a research function.

International Hydrological Decade. The Corps will continue to participate in the International Hydrological Decade (IHD), which is being organized to advance knowledge of the occurrence and movement of water on the earth. The idea for this effort originated in the United States and the program is now under the sponsorship of United Nations Educational Scientific and Cultural Organization (UNESCO). The IHD has been enthusiastically endorsed by many nations of the world. United States support of the plan has been pledged by the President.

The initial IHD effort will involve consideration of problems associated with evaluating the entire picture of global water circulation. These studies will involve four major types of activities: networks of data observations; inventories of streams, lakes, and glaciers; research; and education and the exchange of knowledge.

The U.S. National Committee of IHD was established by the National Academy of Sciences at the request of the U.S. State Department to advise the Government on U.S. participation in the IHD. A representative of the Corps of Engineers is a member of the U.S. National Committee. In fiscal year 1966 the Corps transferred funds to the State Department in support of activities of the Ad Hoc U.S. National Committee. In addition, the Corps continued plans for several scientific investigations under IHD for the development of generalized hydrologic design criteria for widespread use.

Plan formulation and evaluation studies.

(1) Impact of water resource development on economic growth. Under a pair of related and closely coordinated research contracts with the University of Washington at St. Louis and with North Carolina State of the University of North Carolina at Raleigh, investigations were continued on the impact of water resource development on economic growth. This composite research project is aimed at formulating concepts and techniques for determining the extent to which investments in water resource development contribute to national, regional, and local economic growth. These studies are expected to provide key inputs to the formulation and evaluation of the comprehensive resources plan for Appalachia and additional future regional development programs.

(2) *Economic evaluation of navigation improvements.* A research contract was underway with Northwestern University for studies aimed at strengthening the evaluation of benefits from

improvements for waterborne navigation, by developing data and techniques for properly measuring the savings in transportation costs for movements by waterway.

(3) *National Academy of Sciences Committee on Water.* In conjunction with several other water resources agencies, the Corps continued its share of support of the Ad Hoc Committee on Water established by the National Academy of Sciences—National Research Council. This Committee is composed of persons from within and outside of the Federal government who are actively engaged in water resources research, planning, management, and education. The Committee is charged with making scientific and technical studies relevant to development of national programs in the fields of scientific hydrology, water as a natural resource, and education relevant to these programs.

CHAPTER IV

POLICY AND LEGISLATIVE DEVELOPMENTS

The year ending June 30, 1966, was notable for the progress made in the policy field. Major steps were taken to improve the policies, standards, and procedures governing those programs through which the Federal government participates in the development, utilization, and conservation of the Nation's water and related resources. Outstanding developments were: Implementation of some important recommendations of a Civil Works Study Board established by the Secretary of the Army; enactment of the Water Resources Planning Act of 1965 and the creation thereby of the Water Resources Council; and, establishment of important new legislative policies by a number of laws enacted during the fiscal year, and especially the Water Resources Planning Act (July 22, 1965), the Flood Control and River and Harbor Act (Oct. 27, 1965), and the Federal Water Project Recreation Act (July 9, 1965).

1. POLICY DEVELOPMENTS

Implementation of recommendations of the Civil Works Study Board. One of the major recommendations of the Civil Works Study Board, in a report submitted to the Secretary of the Army in January 1965, called for a strengthening of the organizational machinery by which the Corps of Engineers keeps abreast of policy needs, and acts to meet those needs. During fiscal year 1966 the Chief of Engineers moved vigorously to implement this recommendation. In February 1966 a Policy and Analysis Division was established within the Civil Works Directorate and charged with responsibility for coordinating the formulation of all substantive policies developed within the Directorate, coordinating Corps of Engineers activities in the policy field with similar activities in the Water Resources Council, the Bureau of the Budget, and other agencies, and otherwise improving policies of the Corps of Engineers. Plans were completed for a comprehensive review of policy problems and needs to be carried out during fiscal year 1967.

The Water Resources Planning Act and the Water Resources Council. By enactment of the Water Resources Planning Act the Congress adopted a policy of encouraging the conservation, development, and utilization of water and related land resources on a comprehensive and coordinated basis. This act established the Water Resources Council (composed of the Secretaries of Interior; Agriculture; Army; and Health, Education, and Welfare; and the Chairman of the Federal Power Commission) and directed it to establish policies and standards to govern Federal agencies in planning and carrying out water resource development programs. The policies and standards being developed by the Council will replace the "Policies, Standards and Procedures in the Formulation, Evaluation, and Review of Plans for Use in Development of Water and Related Land Resources" issued by the President in 1962, and printed as Senate Document 97, 87th Congress. In carrying out its assignment the Council is assisted by interagency committees and ad hoc task forces. The Department of the Army is represented on the committees and task forces of the Council by personnel of the Civil Works Directorate.

The 1962 Presidential policies and standards of Senate Document 97 are incomplete insofar as cost-sharing and cost-allocation are concerned. The Water Resources Council is concentrating on the task of completing these policies and standards. During fiscal year 1966 the Council also initiated work on a number of emerging policy problems of great importance.

Legislative Policies. Important new legislative policies were established during the year. Public Law 89–298 established a precedent by authorizing a comprehensive study of the water supply needs of the northeastern United States, and the development of a plan for meeting those needs. This constitutes a recognition on the part of the Congress that works for providing water supplies to the great and rapidly growing metropolitan areas of the Nation must become integral and coordinated components of comprehensive regional plans for meeting all water development needs. The 1965 act also gave further support to the policy of comprehensive development of water resources by authorizing the Corps of Engineers to prepare comprehensive plans for a number of regions. During the year another important precedent in the policy field was established by the initiation of a broad planning effort especially designed to *induce* economic development within the Appalachian Region. This new approach

to water resource planning was made possible by the Appalachian Regional Development Act of 1965. The year was marked also by a radical change in Congressional policy on providing for the recreational use of Federal water resource developments. The Federal Water Project Recreation Act (Public Law 89–72) established a Federal policy designed to encourage and assist States and other non-Federal public bodies to assume responsibility for the development of the recreational potentials of such developments. Under this act the Federal government may assume one-half of the cost of recreational facilities which such non-Federal bodies agree to operate and maintain. The policy also limits Federal development of such potentials when non-Federal bodies decline to assume responsibility.

2. LEGISLATIVE ACTIVITIES

The Secretary of the Army was called upon by the Committees of Congress to submit his views on numerous legislative proposals which would affect the development, use, or conservation of water and related resources. The Corps of Engineers assisted in the preparation of the Secretary's reports on these bills. Also during the year the Civil Works Directorate and the General Counsel participated, generally at the request of the Bureau of the Budget, in the development of legislative proposals being considered for submission to Congress by the Executive Branch. Another important task initiated during fiscal year 1966 was that of codifying all laws relating to the Civil Works Program. This work is being done pursuant to section 313, River and Harbor Act of 1965, approved October 27, 1965.

CHAPTER V

CONSTRUCTION AND OPERATIONS

During the fiscal year the Civil Works Program of the Corps, comprising navigation, flood control, and multiple-purpose projects and various related activities, was diligently prosecuted. Progress in carrying out project construction and placing additional works in useful operation was notable. Construction was initiated on 74 new projects and on new items at 19 features of the Mississippi River and tributaries flood control project. Also, construction operations were carried out on 204 additional projects and at additional features of the Mississippi River and tributaries project. Ninety-eight other projects, including 17 projects which were initiated, in addition to items at 12 features of the Mississippi River and tributaries flood control project were placed in beneficial operation. Features at three multiple-purpose projects were placed in operation during the year. Major structural rehabilitation was carried out during the year on 40 channel and harbor projects, one reservoir project, and one multiple-purpose project. Minor structural rehabilitation was conducted on 14 navigation projects, two flood control projects, and one multiple-purpose project.

A summary of project construction and operations by classes follows:

1. NAVIGATION

The present program for rivers and harbors as specifically authorized by Congress includes projects located throughout the United States, Puerto Rico, and the Virgin Islands. These projects are of various types; deep-draft harbors accommodating ocean-going vessels, shallow-draft channels for general small-boat navigation, inland waterways for commercial barge navigation, and the Great Lakes harbors and connecting waterways.

Construction. During the fiscal year active construction operations were carried out on 95 channel and harbor projects and 25

lock and dam projects, of which 39 were placed in useful operation as listed in table 1.

In fiscal year 1966 work was initiated on 22 channel and harbor projects and three lock and dam projects as listed in table 2 and six channel and harbor projects shown in table 1 that were placed in useful operation.

The 56 navigation projects having major construction activity underway at the end of the fiscal year, exclusive of the 25 new starts listed in table 2, are shown in table 3.

Construction operations were also carried out pursuant to the small navigation projects, in accordance with section 107, Public Law 86–645. Nineteen projects not specifically authorized by Congress were placed in useful operation during the year of which nine were initiated. Of the 14 projects initiated, construction continued on 5 projects.

Maintenance. Maintenance and operation activities were conducted on navigation projects during the fiscal year at a cost of $121,870,751. In addition, costs of $6,600,897 were incurred on activities for the protection of navigation and surveys of the north central lakes. In allocating the funds being provided for project maintenance, every effort consistent with budgetary requirements is made to maintain navigation projects adequately to serve the reasonable requirements of commerce and navigation.

Rehabilitation. During the fiscal year, advance engineering and design activities were conducted on two major rehabilitation

Table 1. Navigation Improvements Placed in Useful Operation During the Fiscal Year

Project	*Fiscal year started*	*Date placed in useful operation*	*Nature of improvement*
Bay City Harbor, Wis	1965	Sept. 1965	Dredging.
Boston Harbor (Chelsea River,) Mass	1965	May 1966	Do.
Buffalo Harbor, N.Y. (1962 mod.)	1965	Oct. 1965	Do.
Calumet Harbor and River, Ill. and Ind. (1962 mod.) Phase II	1965	June 1966	Do.
Conneaut Harbor, Ohio	1965	Nov. 1965	Dredging and Structure.
Connecticut River below Hartford (North Cove) Conn	1965	Sept. 1965	Dredging.
Duluth-Superior Inner Harbor, Minn. and Wis	1963	July 1965	Do.
Galveston Harbor and Channel (42 and 40-foot) tex	1965	Oct. 1965	Do.
Gladstone Harbor, Mich	1965	July 1965	Do.

Table 1. Navigation Improvements Placed in Useful Operation During the Fiscal Year
—Continued

Project	*Fiscal year started*	*Date placed in useful operation*	*Nature of improvement*
Gloucester Harbor, Mass	1965	July 1965	Do.
Gulf Intracoastal Waterway, Channel to Palacios, Tex	1966	May 1966	Dredging and breakwaters.
Hammond Bay Harbor, Mich	1962	July 1965	Do.
Houston Ship Channel, Tex. (40-foot)	1961	Feb. 1966	Dredging.
Hudson River, N.Y. (1954 mod.)	1960	Apr. 1966	Dredging and rock removal.
Kennebunk River, Maine	1965	Nov. 1965	Dredging and jetty extension.
Kenosha Harbor, Wis. (1962 mod.)	1964	July 1965	Dredging.
Kewaunee Harbor, Wis. (1935 mod.)	1966	Oct. 1965	Do.
Little Lake Harbor, Mich	1962	July 1965	Dredging and breakwaters.
Lorain Harbor, Ohio (1960 mod.)	1965	June 1966	Do.
Lynnhaven Inlet, Va	1966	Jan. 1966	Dredging.
Mamaroneck Harbor, N.Y. (1960 mod.)	1966	May 1966	Do.
Masonboro Inlet (jetties), N.C	1965	June 1966	Dredging and Jetty.
Matagorda Ship Channel	1962	Jan. 1966	Dredging and jetties.
Mississippi River, Baton Rouge to Gulf, La. (1945 mod.)	1960	July 1965	Dredging and construction.
Mobile Harbor, Ala	1964	July 1965	Dredging.
Narraguagus River, Maine	1965	Feb. 1966	Do.
Oswego Harbor, Ohio (1962 mod.)	1965	Nov. 1965	Do.
Pascagoula Harbor, Miss	1963	Aug. 1965	Do.
Pawtuxet Cove, R.I	1965	Apr. 1966	Dredging and dike construction.
Pepin Harbor, Wis	1966	Sept. 1966	Dredging.
Port Aransas-Corpus Christi Waterway, Tex. (40-foot)	1963	Oct. 1965	Do.
Portsmouth Harbor-Piscatagua River, N.H., and Maine	1965	Jan. 1966	Do.
Sandusky Harbor, Ohio (1960 mod.)	1962	Sept. 1965	Do.
Savannah River below Augusta, Ga	1959	July 1965	Dredging and construction.
Saxon Harbor, Wis	1965	Nov. 1965	Dredging and breakwaters.
Seward Harbor, Alaska	1965	Oct. 1965	Dredging.
Sitka Harbor, Alaska	1965	Dec. 1965	Dredging and breakwater.
Tampa Harbor (Ybor Channel), Fla	1965	Oct. 1965	Dredging.
Waukegon Harbor (1945 mod.)	1966	June 1966	Do.

Table 2. Navigation Improvements Initiated During the Fiscal Year

Project	*Date started*	*Scheduled fiscal year completion*	*Nature of project*
Anchorage Harbor, Alaska	June 1966	1967	Dredging.
Andalusia Harbor, Ill	Oct. 1965	1967	Do.
Arkansas River, lock & dam 8, Ark	July 1965	1970	Lock and dam construction.
Arkansas River, lock & dam 13, Ark	Oct. 1965	1970	Do.
Bayou La Batre, Ala	June 1966	1967	Dredging.
Chicago Harbor, Ill. (1962 mod.)	Apr. 1966	1967	Do.
Coos and Millicoma Rivers, Ore	Aug. 1965	1967	Do.
Dana Point Harbor, Calif	June 1966	1967	Dredging and breakwater.
Erie Harbor, Pa.(1962 mod.)	June 1966	1967	Dredging.
Galveston Harbor & Channel, Tex. (36-foot)	Apr. 1966	1967	Do.
Halfmoon Bay Harbor, Calif	May 1966	1967	Breakwater.
Hannibal locks & dam, Ohio River, Ohio and W. Va	Mar. 1966	1972	Replacement for existing locks and dams 12-4, inclusive.
Kaskaskia River, Ill	June 1966	1972	Lock, dam, and channel.
Kingston Harbor, Wash	June 1966	1967	Dredging and breakwater.
Leland Harbor, Mich	June 1966	1968	Do.
Little Neck Bay, N.Y.	May 1966	1969	Dredging.
Milwaukee Harbor, Wis	July 1965	1967	Do.
Minnesota River, Minn	May 1966	1968	Do.
Norfolk Harbor (Hampton Roads), Va	Mar. 1966	1969	Do.
Plymouth Harbor, Mass	June 1966	1968	Dredging and breakwater.
Rollison Channel, N.C	May 1966	1967	Dredging.
Texas City Channel, Tex. (40-foot)	May 1966	1967	Do.
Wallisville Reservoir	May 1966	1969	Construction of channel, lock and dam.
Warsaw, Ill	Mar. 1966	1967	Dredging.
Wilmington Harbor, N.C	Apr. 1966	1968	Do.

navigation projects at a cost of $4,092. Major structural rehabilitation was carried out on 40 navigation projects at a cost of $12,182,557. Minor structural rehabilitation was actively prosecuted on 14 navigation projects at a cost of $1,375,265.

2. BEACH EROSION CONTROL

The policy of Federal assistance in construction of works for

Table 3. Navigation Improvements Under Construction During Fiscal Year 1966

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Nature of improvement*
Apalachicola River Channel, Fla	1963	1969	Dredging and regulating works.
Aquatic Plant Control	1959	1967	Control and eradication of aquatic plants.
Arkansas River and tributaries, Arkansas and Oklahoma	1950	1970	Bank stabilization.
Arkansas River, lock & dam 1, Arkansas	1963	1967	Lock and dam construction.
Arkansas River, lock & dam 2, Arkansas	1963	1969	Do.
Arkansas River, lock & dam 3, Arkansas	1964	1968	Do.
Arkansas River, lock & dam 4, Arkansas	1964	1969	Do.
Arkansas River, lock & dam 5, Arkansas	1965	1969	Do.
Arkansas River, lock & dam 7, Arkansas	1965	1969	Do.
Arkansas River, lock & dam 9, Arkansas	1965	1970	Do.
Baltimore Harbor and Channels, Md	1961	1967	Dredging.
Bayou Lafourche and Lafourche Jump Waterway, La	1963	Indefinite	Dredging and structure.
Belleville locks & dam, Ohio River, Ohio and W. Va	1962	1968	Replacement for existing locks and dams 18–20, inclusive.
Calcasieu River and Pass, La	1962	1969	Dredging.
Calcasieu River Salt Water Barrier, La	1965	1968	Dredging and structures.
Calumet Harbor and River, Ill. & Ind. (1960 mod.)	1962	1967	Dredging.
Cal-Sag modification, Illinois Waterway, Ill. and Ind	1955	1969	Channel improvements and relocations.
Canaveral Harbor, Fla	1964	1970	Construction-channel, lock and dam.
Cannelton locks and dam, Ohio River, Ind. and Ky	1962	1971	Replacement for existing locks and dams 43–45, incl.
Claiborne lock and dam, Alabama River, Ala	1965	1969	Construction of lock and dam.

Table 3. Navigation Improvements Under Construction During Fiscal Year 1966
—Continued

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Nature of improvement*
Cleveland Harbor, Ohio (1958 mod.)	1964	1971	Dredging and replacement of bridges.
Columbia and Lower Willamette Rivers, Wash. and Oreg. (40-foot mod.)	1964	1968	Rock removal.
Cross-Florida Barge Canal	1964	Indefinite	Construction—locks, dam and canal.
David D. Terry lock & dam (lock & dam 6), Arkansas River, Ark.	1965	1969	Lock and dam construction.
Delaware River, Pa. N.J., & Del., Philadelphia to sea (anchorage)	1964	1970	Dredging.
Detroit River, Mich	1957	1970	Dredging and compensating works.
Freshwater Bayou, La	1963	Indefinite	Dredging and lock construction.
Great Lakes to Hudson River Waterway, N.Y	1954	1969	Dredging, lowering sills on locks and guard gates and raising bridges.
Gulf Intracoastal Waterway, Guadalupe River Channel to Victoria, Tex	1958	1967	Dredging and bridge construction.
Holt lock and dam, Warrior and Tombigbee Rivers, Ala	1962	1968	Replacement for existing locks and dams 13–16, incl.
Inland Waterway, Delaware River to Chesapeake Bay, Del. & Md. Part II	1962	1970	Dredging and bridge construction.
Intracoastal Waterway, Caloosahatchee River to Anclote River, Fla	1960	1967	Dredging.
Kahalui Harbor, Mauai, Hawaii	1965	1967	Dredging and breakwater.
Manistee Harbor, Mich	1962	1967	Dredging.
Maxwell locks and dam, Monongahela River, Pa	1961	1968	Replacement for existing locks and dams 5 and 6.
McAlpine locks and dam, Ohio River, Ind. and Ky	1957	1966	Reconstruction and modernization of locks and dam 41.
Mississippi River between Ohio & Missouri Rivers	1910	1970	Regulating works.

Table 3. Navigation Improvements Under Construction During Fiscal Year 1966
—Continued

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Nature of improvement*
Missouri River—Kansas City to mouth	1912	1967	Navigation and bank stabilization.
Missouri River—Kansas City to Sioux City, Iowa (Rulo, Nebr., to Kansas City)	1928	1967	Do.
Missouri River—Kansas City to Sioux City, Iowa (Sioux City to Rulo, Neb.)	1928	1969	Bank stabilization.
Newbourgh locks & dam, Ohio River, Ind. & Ky	1965	1973	Replacement for existing locks and dams 46 and 47.
Opekiska lock and dam, Monongahela River, W. Va	1961	1967	Replacement for existing locks and dams 14 and 15.
Ouachita and Black Rivers, Ark. and La	1964	1973	Columbia lock and dam.
Palm Beach Harbor, Fla	1964	1967	Dredging.
Pike Island locks and dam, Ohio River, W. Va	1959	1967	Replacement for existing locks and dams 10 and 11.
Poe lock, Michigan	1961	1968	Replacement for existing Poe lock.
Portland Harbor, Maine	1963	1967	Dredging.
Racine locks and dam, Ohio River, Ohio and W. Va	1964	1970	Replacement for existing locks and dams 21–23, inclusive.
Reconstruction of dam 4, Monongahela River, W. Va	1963	1967	Reconstruction of dam and lock modification.
Sabine—Neches Waterway (40-foot channel), Tex	1965	1969	Dredging and bridge construction.
St. Clair River, Mich	1959	1970	Dredging and compensating works.
St. Marys River, Mich	1958	1968	Dredging.
Tacoma Harbor, Wash. (1962 mod.)	1965	1967	Do.
Toledo Harbor, Ohio	1962	1967	Do.
Uniontown locks and dam, Ohio River, Ind. and Ky	1965	1972	Replacement for existing locks and dams 48 and 49.
Yaquina Bay and Harbor, Ore	1963	1968	Dredging and jetty extension.

the restoration and protection of shores against erosion by waves and currents applies to shores of the United States, its territories and possessions, that are owned by States, municipalities, or other political subdivisions, and also to shores other than public if there is a benefit such as that arising from public use or from the protection of nearby public property or if the benefits to those shores are incidental to the project. The costs of restoration and protection of Federal property are borne fully by the Federal government. Federal participation in the costs of a project for restoration and protection of State, county, and other publicly-owned shore parks and conservation areas may be, at the discretion of the Chief of Engineers, not more than 70 percent of the total cost exclusive of land costs, when such areas—

(*a*) Include a zone which excludes permanent human habitation.

(*b*) Include but are not limited to recreational beaches.

(*c*) Satisfy adequate criteria for conservation and development of the natural resources of the environment.

(*d*) Extend landward a sufficient distance to include, where appropriate, protective dunes, bluffs or other natural features which serve to protect the uplands from damage.

(*e*) Provide essentially full park facilities for appropriate public use.

Federal participation in the costs of projects for other non-Federal publicly-owned shores is limited to a maximum of one-half of the total cost. No Federal contribution toward maintenance is authorized, but under certain conditions Federal contributions may be made toward periodic beach nourishment for a length of time specified by the Chief of Engineers in each case.

In addition to Federal participation in complete units of authorized projects, construction work was continued on the Point Mugu-San Pedro, Calif., project. Further construction at the Imperial Beach, and the Ventura-Pierpoint Area, Calif., was deferred pending restudy of the propects and demonstration of the need for further work. The Hamlin Beach, N.H., and Doheny Beach, Calif., projects were placed in useful operation.

3. FLOOD CONTROL (GENERAL)

Construction. During fiscal year, active construction operations were carried out on 161 specifically authorized flood control projects, of which 29 were placed in useful operation, as shown in table 4.

Table 4. Flood Control Projects Placed in Useful Operation During Fiscal Year

Project	*Fiscal year started*	*Date placed in useful operation*	*Nature of project*
Bardwell, Tex	1964	Nov. 1965	Reservoir.
Big Fossil Creek, Tex	1964	Apr. 1966	Local protection.
Bonnes Coulee, Velva, N. Dak.[1]	1966	June 1966	Do.
Butler, Pa	1963	Dec. 1965	Do.
Colfax, Wash	1962	Dec. 1965	Do.
Conant Brook, Mass	1964	May 1966	Reservoir.
Elk City, Kans	1962	July 1965	Do.
Fox Point, R.I	1962	Jan. 1966	Local protection.
Hancock Brook, Conn	1963	May 1966	Reservoir.
Ithaca, N.Y., Cayuga Inlet	1965	Nov. 1965	Local protection.
Kawainui Swamp, Hawaii	1964	May 1966	Do.
Lackawanna, N.Y., Smokes Creek	1965	Oct. 1965	Do.
Little Sioux River, Iowa	1956	June 1966	Do.
Lost River, Minn	1964	Dec. 1965	Do.
Merced River, Calif.[2]	1964	Apr. 1966	Reservoir.
Millwood, Ark	1961	July 1965	Do.
New Bedford, Mass	1963	Jan. 1966	Local protection.
North Fork of Pound, Va	1963	Jan. 1966	Reservoir.
Paint Rock River, Ala	1963	Jan. 1966	Channel improvement.
Salamonie River, Ind	1962	Jan. 1966	Reservoir.
Sid Simpson Flood Control Project (Beardstown, Ill.)	1955	Apr. 1966	Local protection.
Sioux Falls, S. Dak	1956	Oct. 1965	Do.
South River Drainage District, Missouri	1964	May 1966	Do.
Summersville, W. Va	1960	Mar. 1960	Reservoir.
Three Rivers, Mass	1964	Jan. 1966	Local protection.
Tucson diversion channel, Gila River, Ariz	1963	Apr. 1966	Do.
Wailoa Stream and tributaries, Hawaii	1964	Sept. 1965	Do.
Washougal Area, Wash	1965	May 1966	Do.
Wrightsville Beach, N.C	1965	Aug. 1965	Do.

[1] This is also a new start for fiscal year 1966.
[2] Being developed by local interests—Federal contribution for providing flood control storage.

During the year, excluding multiple-purpose projects, work was initiated on 24 specifically authorized flood control projects, as shown in table 5.

The 108 flood control projects under active construction during the fiscal year, exclusive of multi-purpose projects and those projects placed in useful operation or initiated during the year as shown in tables 4 and 5, are listed in table 6.

Construction operations were also carried out pursuant to the

small-project authority in section 205, 1948 Flood Control Act, as amended. Ten small projects were placed in useful operation pursuant to this program and five new projects were initiated during the year. Construction was continued on one project.

Maintenance. Maintenance and operation activities were conducted on 171 flood control projects during the fiscal year at a cost of $14,744,517. In addition, inspection of completed local flood protection works constructed by the Corps but operated and maintained by local interests and scheduling of flood control operations for reservoirs of other Federal agencies cost $815,339.

Rehabilitation. Major rehabilitation was conducted on one res-

Table 5. Flood Control Projects Initiated During Fiscal Year 1966

Project	*Date started*	*Scheduled fiscal year completion*	*Nature of project*
Beltzville, Pa	July 1965	1969	Reservoir.
Black Rock, Conn	May 1966	1969	Do.
Brookville, Ind	Nov. 1965	1971	Do.
Carr Fork, Ky	Jan. 1966	1969	Do.
Cave Run, Ky	July 1965	1970	Do.
DeQueen, Ark	Apr. 1966	1971	Do.
Des Moines and Mississippi Levee District No. 1, Missouri	June 1966	1968	Local protection.
East Point, La	Apr. 1966	1967	Do.
Four Rivers Basin, Fla	Apr. 1966	After 1971	Do.
Hanapepe River, Hawaii	Dec. 1965	1967	Do.
Henderson County Drainage District No. 1, Illinois	Apr. 1966	1968	Do.
Henderson County Drainage District No. 2, Illinois	Apr. 1966	1967	Do.
Kaw, Okla	June 1966	1973	Reservoir.
Latrobe, Pa	July 1965	1967	Local protection.
Little Papillion Creek, Nebr	Oct. 1965	1968	Do.
Midland Drainage District, Oregon	May 1966	1967	Do.
Norfolk, Nebr	June 1966	1968	Do.
Optima, Okla	Mar. 1966	1972	Reservoir.
Paint Creek, Ohio	June 1966	1970	Do.
Port Arthur and vicinity, Texas	Mar. 1966	1971	Hurricane-flood protection.
Redwood Creek, Calif	May 1966	1969	Channel improvements.
River Rouge, Mich	June 1966	1969	Local protection.
South Quincy Drainage and Levee District, Illinois	Apr. 1966	1968	Do.
South St. Paul, Minn	Nov. 1965	1968	Do.

Table 6. Flood Control Projects Under Construction During Fiscal Year 1966

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Nature of project*
Alameda Creek, Calif	1965	1970	Channel improvements.
Alamo, Ariz	1963	1968	Reservoir.
Albuquerque Diversion Channels, New Mexico	1965	1968	Local protection.
Allegheny River, Pa. and N.Y	1960	1968	Reservoir.
Battle Creek, Kalamazoo River, Mich	1957	Indefinite	Local protection.
Bear Creek, Calif	1963	1967	Do.
Black Butte, Calif	1960	1967	Reservoir.
Blanchard, Pa	1965	1970	Do.
Blue River, Oreg	1963	1968	Do.
Bowman-Haley, N. Dak	1964	1967	Do.
Buffalo Bayou and tributaries, Texas	1965	1969	Local protection.
Campti-Clarence Levee District, Louisiana	1965	1968	Do.
Canyon, Tex	1958	1967	Reservoir.
Carlyle, Ill	1958	1967	Do.
Central and Southern Florida	1950	After 1971	Local protection.
Chariton River, Mo	1948	1969	Do.
Cochiti, N. Mex	1965	1972	Reservoir.
Colebrook River, Conn. and Mass	1956	1969	Do.
Cowlitz County Diking Improvement District No. 15, Washington	1965	1966	Local protection.
Curwensville, Pa	1962	1967	Reservoir.
Deer Creek, Ohio	1965	1968	Do.
East Lynn, W. Va	1965	1970	Do.
East St. Louis, Ill	1937	1967	Local protection.
Eau Galle River, Wis	1964	1969	Reservoir and channel improvements.
Elkland, Pa	1964	1967	Local protection.
Endicott, Johnson City, and Vestal, N.Y	1957	1966	Do.
Evansville, Ind	1939	Indefinite	Do.
Fall Creek, Oreg	1962	1966	Reservoir.
Fire Island Inlet to Montauk Point, N.Y	1965	1976	Local protection.
Fishtrap, Ky	1962	1968	Reservoir.
Floyd River, Sioux City, Iowa	1961	1966	Local protection.
Fort Worth Floodway (Clear Fork), Tex	1965	1970	Do.
Fort Worth Floodway (West Fork), Tex	1965	1968	Do.
Freeport and vicinity, Texas	1965	1970	Hurricane-flood protection.
Galisteo, N. Mex	1965	1970	Reservoir.
Garland City, Ark	1963	1968	Local protection.
Gering Valley, Nebr	1964	1968	Do.

Table 6. Flood Control Projects Under Construction During Fiscal Year 1966—Continued

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Nature of project*
Gillham, Ark	1963	1970	Reservoir.
Grayson, Ky	1964	1967	Do.
Green Bay Levee and Drainage District No. 2, Iowa	1964	1967	Local protection.
Green River, Ky	1964	1968	Reservoir.
Hop Brook, Conn	1965	1968	Do.
Hunt Drainage District and Lima Lake Drainage District, Illinois	1961	1968	Local protection.
Huntington, Ind	1963	1968	Reservoir.
Iowa River Flint Creek Levee District No. 16, Iowa	1963	1968	Local protection.
Isabella, Calif	1948	1967	Reservoir.
Jackson and East Jackson, Miss	1965	1967	Local protection.
Kansas Citys, Kans. and Mo	1940	Indefinite	Do.
Levee unit 5, Wabash River, Indiana	1964	1968	Do.
Los Angeles County Drainage Area, California	1935	1968	Do.
Lower Columbia River Basin bank protection works, Oregon and Washington	1961	1975	Do.
Lower San Joaquin River, Calif	1957	1968	Levees and channels.
Lower Woonsocket, R.I	1964	1967	Local protection.
Marion, Kans	1964	1968	Reservoir.
Marion County Drainage District, Missouri	1965	1967	Local protection.
Middle Creek, Calif	1959	1967	Do.
Milford, Kans	1962	1967	Reservoir
Mississinewa River, Ind	1962	1967	Do.
Missouri River Agricultural Levees, Iowa, Kans., Nebr., and Mo	1948	Indefinite	Local protection.
Missouri River, Garrison to Oahe, N. Dak. and S. Dak	1965	1968	Bank stabilization.
Missouri River Agricultural Levee, Sioux City to Mouth (Sioux City, Iowa to Rulo, Nebr.)	1948	Not scheduled	Local protection.
Muscatine Island Levee District and Muscatine-Louisa County Drainage District No. 13, Iowa	1960	1968	Do.
Navarro Mills, Tex	1959	1966	Reservoir.
New Athens, Ill	1965	1968	Local protection.
New Hogan, Calif	1960	1967	Reservoir.
Norfolk, Va	1965	1968	Local protection.
Okatibbee, Miss	1965	1968	Reservoir.
Oroville, Calif.[1]	1957	1968	Do.

See footnote at end of table

Table 6. Flood Control Projects Under Construction During Fiscal Year 1966—Continued

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Nature of project*
Pat Mayse, Tex	1965	1967	Do.
Perry, Kans	1964	1969	Do.
Perry County, Mo	1937	1967	Local protection.
Pine Creek, Okla	1963	1969	Reservoir.
Pine Flat, Calif	1947	1968	Reservoir and channel improvement.
Proctor, Tex	1960	1966	Reservoir.
Raritan Bay and Sandy Hook Bay, N.J	1965	1970	Local protection.
Rathbun, Kans	1964	1969	Reservoir.
Red River below Denison Dam, levees and bank stabilization, La. and Tex	1948	1968	Local protection.
Red Rock, Iowa	1960	1969	Reservoir.
Rend Lake, Ill	1965	1970	Do.
Sacramento River Bank Protection, Calif	1963	1973	Local protection.
Sacramento River Flood Control, Calif	1918	1967	Do.
Sacramento River, major and minor tributaries, Calif	1949	1971	Do.
Saginaw River, Mich	1965	Indefinite	Do.
St. Louis, Mo	1959	1969	Local protection.
Salt Creek and tributaries, Wyoming	1961	1968	Do.
San Antonio Channel Improvement, Texas	1957	1974	Do.
Saylorville, Iowa	1965	1971	Reservoir.
Shelbyville, Ill	1963	1969	Do.
Shenango River, Ohio and Pa	1961	1968	Do.
Sheridan, Wyo	1961	1967	Local protection.
Sny Basin, Ill	1960	1967	Do.
Sny Island Levee Drainage District, Illinois	1965	1969	Do.
Somerville, Tex	1962	1967	Reservoir.
Stamford, Conn	1965	1968	Local protection.
Stillhouse Hollow, Tex	1962	1968	Reservoir.
Subdistrict No. 1 and Bay Island Drainage and Levee District No. 1, Illinois	1963	1967	Local protection.
Success, Calif	1957	1967	Reservoir.
Terminus, Calif	1958	1967	Do.
Texas City, Tex	1962	1969	Hurricane-flood protection.
Tombigbee River tributaries, Miss. and Ala	1965	Not Scheduled	Channel improvement of 22 tributaries.
Topeka, Kans	1938	1969	Local protection.
Turtle Creek, Pa	1963	1968	Do.
Waco, Tex	1958	1967	Reservoir.
Walnut Creek, Calif	1964	1970	Local protection.
West Branch, Mahoning River, Ohio	1963	1968	Reservoir.

Table 6. Flood Control Projects Under Construction During Fiscal Year 1966—Continued

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Nature of project*
Willamette River Basin, Oreg	1938	1969	Local protection.
Winona, Minn	1965	1967	Do.
Wood River, Ill	1947	1966	Do.

[1] Being constructed by local interests. Federal contribution for providing flood control storage.

ervoir project at a cost of $38,315 during the fiscal year. Minor rehabilitation was actively prosecuted on two projects at a cost of $58,978.

4. MULTIPLE-PURPOSE PROJECTS INCLUDING POWER

The importance of multi-purpose projects in relation to the overall activities of the Corps continued to increase during the fiscal year as a result of the large construction program relating to these projects currently underway and the placing in operation of primary-purpose features at several projects. These projects have been designed to serve primarily in the interest of navigation or flood control and the production of hydroelectric power, although frequently other benefits, such as irrigation, pollution abatement, water supply and receration, are also realized.

The inclusion of power features in conjunction with other project features has often resulted in an enhancement of their economic value. Pertinent information on the power aspects of multiple-purpose projects is contained in a subsection below:

Construction. During the year, construction operations were carried out on 30 multiple-purpose projects, of which eight projects had some or all primary features in useful operation at the end of the year. These projects are listed in tables 7 and 8.

Table 7. Multiple-Purpose Projects Completed for Full Beneficial Use This Fiscal Year

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Project primary purpose*
Hills Creek Reservoir, Willamette River, Oreg	1956	1966	Flood control, power, navigation, and irrigation.

Table 8. Multiple-Purpose Projects Under Construction with Some or All Primary Project Features Placed in Useful Operation This Fiscal Year

Project	Fiscal year started	Scheduled fiscal year completion	Features placed in operation during fiscal year	Project primary purposes
Barkley Dam, Cumberland River, Ky. and Tenn.	1957	1967	Flood control and power (4 units)	Navigation,* flood control, and power.
Big Bend Reservoir, Missouri River, S. Dak.	1959	1968	Power—3 units	Flood control,* and power.*
Dardanelle lock and dam (No. 10), Arkansas River, Ark.	1957	1970	Power—2 units	Navigation* and power.*
Keystone Reservoir, Arkansas River, Okla.	1957	1968		Flood control* and power.
Oahe Reservoir, Missouri River, N. Dak. and S. Dak.	1949	1969		Flood control,* navigation,* power,* and irrigation.
Sam Rayburn Reservoir, Tex.	1957	1967	Power—2 units	Flood control* and power.
The Dalles Dam, Columbia River, Oreg. and Wash.	1952	1967		Navigation,* power,* and irrigation.

* Projects operated for these primary purposes at the beginning and throughout the fiscal year.

Of the multiple-purpose projects under active construction at the end of the fiscal year, 22 had no primary features in operation. They are shown in table 9.

Operation and maintenance. Operation and maintenance activities were conducted on 47 multiple-purpose projects during the fiscal year at a cost of $30,956,546.

Rehabilitation Major rehabilitation was conducted on one multiple-purpose project at a cost of $17,793. Minor rehabilitation was conducted on one multiple-purpose project at a cost of $77,476.

Table 9. Multiple-Purpose Projects Under Construction and Not Operating This Fiscal Year

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Project primary purpose*
Broken Bow Reservoir, Mountain Fork River, Okla	1962	1970	Flood control and power.
Carters Dam, Coosawatte River, Ga	1962	1970	Do.
Clarence Cannon Dam, Salt River, Mo	1966	1972	Flood control, power, water supply, and recreation.
Cordell Hull Dam, Cumberland River, Tenn	1963	1972	Navigation, power, and recreation.
Cougar Reservoir, McKenzie River, Oreg	1956	1967	Flood control, power and recreation.
DeGray Reservoir, Caddo River, Ark	1963	1971	Flood control, power, pollution abatement, and water supply.
Dworshak Reservoir, North Fork Clearwater River, Idaho	1963	1973	Navigation and power.
Green Peter Reservoir, Middle Santiam River, Oreg	1961	1968	Flood control, power, and recreation.
J. Percy Priest Reservoir, Stones River, Tenn	1963	1969	Flood control, power, and recreation.
John Day lock and dam, Columbia River, Oreg. and Wash	1958	1972	Navigation and power
Kaysinger Bluff Reservoir, Osage River, Mo	1965	1973	Flood control and power.
Laurel River Reservoir, Laurel River, Ky	1965	1973	Power and recreation.
Libby Reservoir, Kootenai River, Mont	1966	1976	Flood control and power.
Little Goose lock and dam, Snake River, Wash	1963	1971	Navigation and power.
Lower Granite lock and dam, Snake River, Wash	1966	1973	Do.
Lower Monumental lock and dam, River, Wash	1961	1968	Do.
Millers Ferry lock and dam, Alabama River, Ala	1963	1969	Navigation and power.
Ozark lock and dam (No. 12), Arkansas River, Ark	1965	1973	Navigation, power and recreation.

Table 9. Multiple-Purpose Projects Under Construction and Not Operating During Fiscal Year 1966—Continued.

Project	*Fiscal year started*	*Scheduled fiscal year completion*	*Project primary purpose*
Robert S. Kerr lock and dam (No. 15), Arkansas River, Okla	1964	1970	Navigation and power.
Stockton Reservoir, Sac River, Mo	1963	1971	Flood control and power.
Webbers Falls lock and dam (No. 16), Arkansas River, Okla	1965	1970	Navigation and power.
West Point Dam, Chattahoochee River, Ala. and Ga	1966	1973	Flood control and power.

Hydroelectric power. The continuing installation of hydroelectric power generating equipment in multiple-purpose projects emphasizes the importance of power in the expanding water resources development program of the Corps civil works activities. Installed nameplate capacity in operation as of June 30, 1966, increased 4.7 percent over that in operation June 30, 1965. Electric energy production was 11.8 percent above the preceding fiscal year.

Electric power produced at Corps hydroelectric projects in excess of projects needs, must, under existing law and with the exception of one project, be delivered to the Department of the Interior for disposition at rates approved by the Federal Power Commission.

Installed capacity. During the fiscal year, 11 generating units were placed in operation at four projects for a total of 419,500 kilowatts of capacity as shown in table 10. This additional capacity represents 21.4 percent of the hydroelectric capacity and 3.4 per-

Table 10. Generating Capacity Placed in Operation During the Fiscal Year

Projects	*Size of units (kilowatts)*	*Number of units*	*Added capacity (kilowatts)*
Barkley[1]	32,500	4	130,000
Big Bend	58,500	3	175,500
Dardanelle	31,000	2	62,000
Sam Rayburn[1]	26,000	2	52,000
Totals		11	419,500

[1] Initial operation of project.

cent of the total generating capacity added to the Nation's electric utility systems during the fiscal year.

On June 30, 1966, the Corps had 9,431,900 kilowatts of nameplate generating capacity in operation at 45 projects as listed in table 11. This represents 3.9 percent of the total generating capacity and 21.8 percent of the hydroelectric generating capacity in operation throughout the Nation at the end of the fiscal year.

Hydroelectric power production. During the fiscal year, 42.5 billion kilowatt-hours of electric energy was produced at Corps multiple-purpose projects. This was an increase of 4.5 billion kilowatt-hours, or 11.8 percent over the power production of the preceding fiscal year. Power produced at Corps projects during the fiscal year was 3.9 percent of the total power produced in the Nation and 21.8 percent of the hydroelectric power produced. Chart I illustrates the trend of power produced at Corps multiple-purpose projects during the past ten fiscal years.

Additional capacity scheduled. As of June 30, 1966, the Corps of Engineers had scheduled for installation 323,500 kilowatts of generating capacity at three operating projects and 5,724,200 kilowatts of capacity at 23 projects under construction for a total of 6,047,700 kilowatts. The additional capacity is listed by projects in tables 11 and 12.

Projects in operation and under construction have an ultimate capacity of 20,695,600 kilowatts. Generating capacity scheduled for operation in fiscal year 1967 is 80,000 kilowatts for a total of 9,511,900 kilowatts of capacity in operation by June 30, 1967. Chart II shows the continuing increase in installed capacity at Corps multiple-purpose projects for fiscal year 1961 through 1966, and scheduled for fiscal years 1967 and 1968.

5. FLOOD CONTROL, MISSISSIPPI RIVER AND TRIBUTARIES

Alluvial Valley

The project for Mississippi River and tributaries authorized by the 1928 Flood Control Act and amendments, provides for flood protection of its alluvial valley below Cape Girardeau, Mo., from Mississippi River and local floods by means of levees and floodwalls, channel realignment and stabilization, reservoirs, floodways and outlets, and drainage. A summary of the authorizing act and amendments are in Vol. 2, 1966 Annual Report, Mississippi River Commission in the tabulation following table C.

The total authorization for the project at the end of the fiscal

Table 11. Hydroelectric Projects in Operation June 30, 1966

Projects	Initial operation in fiscal year	Nameplate capacity kilowatts — Existing installation	Scheduled installation	Ultimate installation
Albeni Falls, Idaho	1955	42,600		42,600
Allatoona, Ga	1950	74,000		110,000
Barkley, Ky. and Tenn	1966	130,000		130,000
Beaver, Ark	1965	112,000		112,000
Big Bend, S. Dak	1965	409,500	58,500	468,000
Blakely Mountain, Ark	1956	75,000		75,000
Bonneville, Oreg. and Wash	1938	518,400		518,400
Buford, Ga	1957	86,000		86,000
Bull Shoals, Ark. and Mo	1953	340,000		340,000
Center Hill, Tenn	1951	135,000		135,000
Cheatham, Tenn	1958	36,000		36,000
Chief Joseph, Wash	1956	1,024,000		1,728,000
Clark Hill, Ga. and S.C	1953	280,000		280,000
Cougar, Oreg	1964	25,000		60,000
Dale Hollow, Tenn	1949	54,000		54,000
Dardanelle, Ark	1965	124,000		124,000
Denison, Okla. and Tex	1945	70,000		175,000
Detroit, Oreg	1954	118,000		118,000
Eufaula, Okla	1965	90,000		90,000
Fort Gibson, Okla	1953	45,000	22,500	67,500
Fort Peck, Mont	1944	165,000		165,000
Fort Randall, S. Dak	1954	320,000		320,000
Garrison, N. Dak	1956	400,000		400,000
Gavins Point, Nebr. and S. Dak	1957	100,000		100,000
Greers Ferry, Ark	1964	96,000		96,000
Hartwell, Ga. and S.C	1962	264,000		330,000
Hills Creek, Oreg	1962	30,000		30,000
Ice Harbor, Wash	1962	270,000		540,000
Jim Woodruff, Fla. and Ga	1957	30,000		30,000
John H. Kerr, N.C. and Va	1953	204,000		204,000
Lookout Point, Oreg	1955	135,000		135,000
McNary, Oreg. and Wash	1954	980,000		1,400,000
Narrows, Ark	1950	17,000	8,500	25,500
Norfork, Ark. and Mo	1944	70,000		140,000
Oahe, N. Dak. and S. Dak	1962	595,000		595,000
Old Hickory, Tenn	1957	100,000		100,000
Philpott, Va	1954	14,000		14,000
Sam Rayburn, Tex	1966	52,000		52,000
St. Marys, Mich	1952	18,400		18,400
Table Rock, Ark. and Mo	1959	200,000		200,000
Tenkiller Ferry, Okla	1954	34,000		34,000
The Dalles, Oreg. and Wash	1957	1,119,000	234,000	1,743,000
Walter F. George, Ala. and Ga	1963	130,000		130,000
Whitney, Tex	1954	30,000		30,000
Wolf Creek, Ky	1952	270,000		270,000
Total, in operation		9,431,900	323,500	11,851,400

HYDROELECTRIC POWER PRODUCTION

NET ANNUAL KILOWATT-HOURS

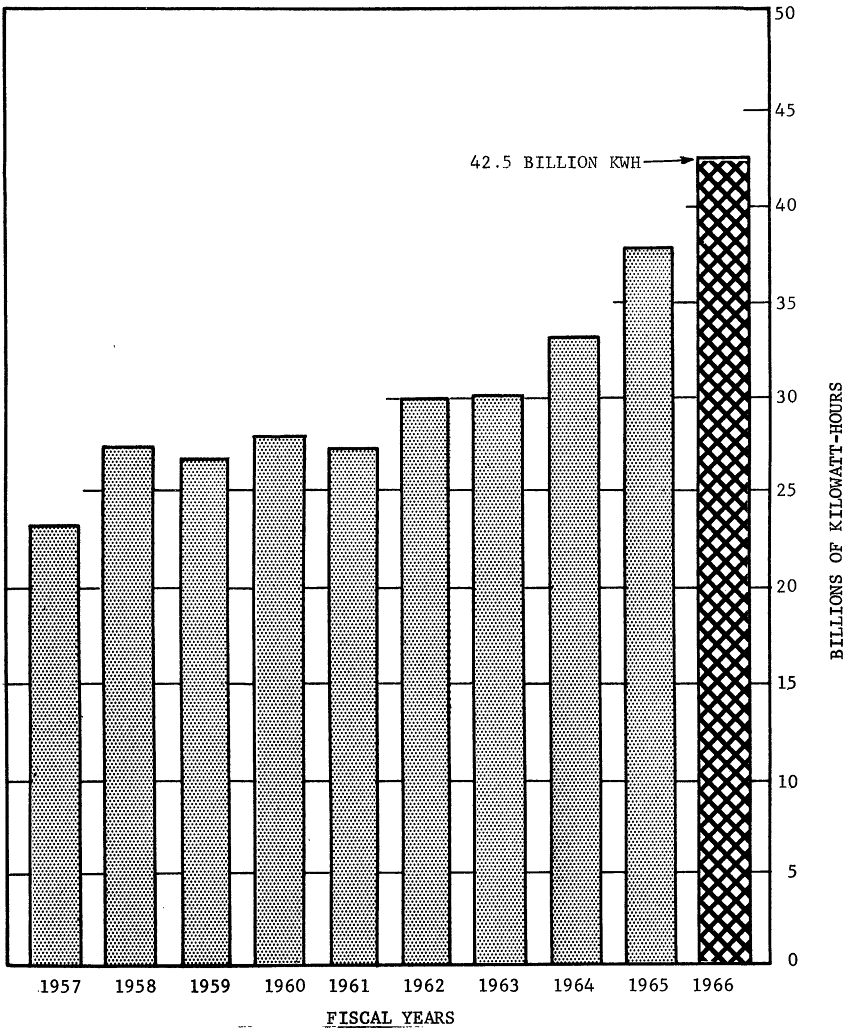

CHART I

year is $1,684,922,600, of which $1,426,946,100 has been appropriated and $1,423,474,000 expended.

Construction. During the year, construction was completed on 12 features of the project as shown in table 13, and one feature of the project was placed in useful operation, as shown in table 14. During the year, progress was made in the continuing construction of the principal features of the project on the main stem and on

HYDROELECTRIC GENERATING CAPACITY
OPERATING AND SCHEDULED

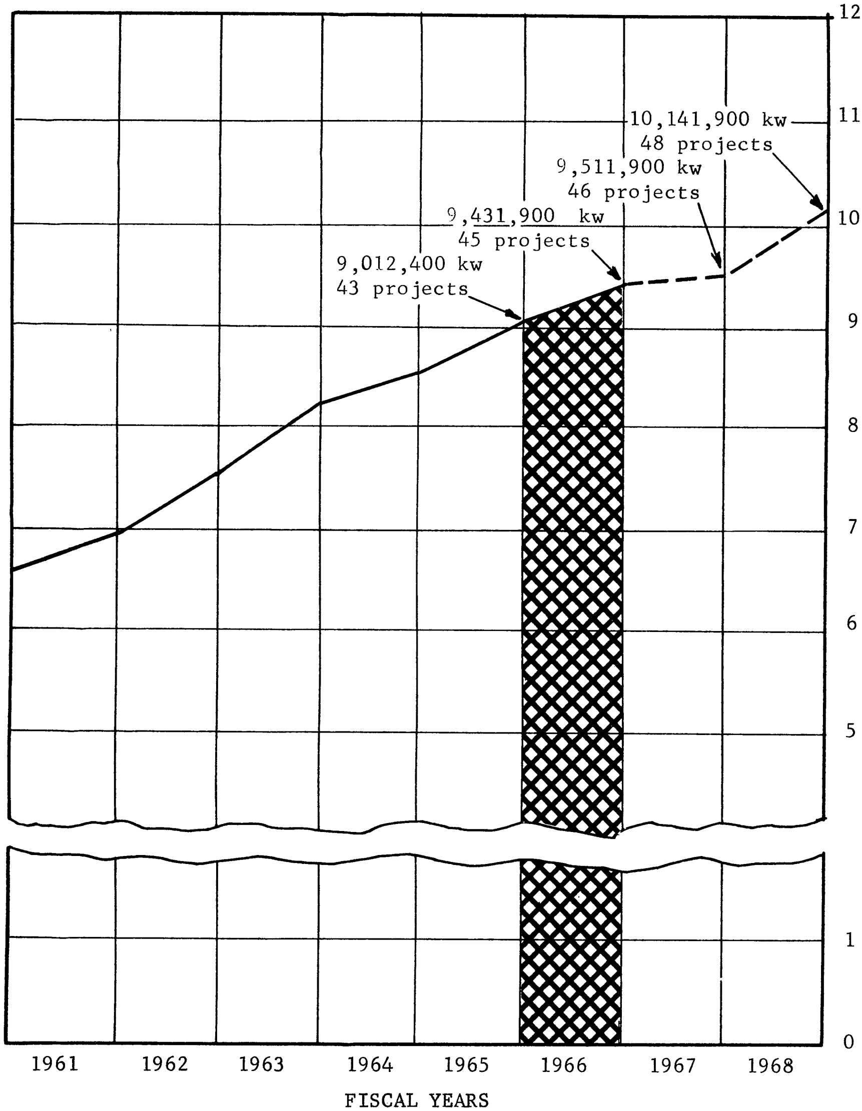

CHART II

the tributaries in the alluvial valley. Main stem work on levees, revetments, dikes, and dredging was accomplished as follows: Main line levees enlarged to grade and section, 5.9 miles; new bank protection placed, 24.6 miles; dikes constructed, 8.8 miles;

Table 12. Hydroelectric Projects Under Construction June 30, 1966 (no generating units in operation)

Projects	Scheduled for operation in fiscal year	Nameplate capacity—kilowatts: Existing installation	Scheduled installation	Ultimate installation
Broken Bow, Okla	1969		100,000	100,000
Carters, Ga	1970		250,000	500,000
Clarence F. Cannon, Mo	Not scheduled		70,000	70,000
Cordell Hall, Tenn	1971		100,000	100,000
DeGray, Ark	1971		68,000	68,000
Dworshak, Idaho	1972		400,000	1,060,000
Green Peter, Oreg	1967		100,000	100,000
John Day, Oreg. and Wash	1968		2,160,000	2,700,000
Jones Bluff, Ala	1973		68,000	68,000
J. Percy Priest, Tenn	1969		28,000	28,000
Kaysinger Bluff, Mo	1972		152,000	152,000
Keystone, Ark	1968		70,000	70,000
Laurel, Ky	1973		61,000	61,000
Libby, Mont	1973		420,000	840,000
Little Goose, Wash	1970		405,000	810,000
Lower Granite, Wash	1971		405,000	810,000
Lower Monumental, Wash	1970		405,000	810,000
Millers Ferry, Ala	1969		75,000	75,000
Ozark, Ark	1971		100,000	100,000
Robert S. Kerr, Okla	1970		110,000	110,000
Stockton, Mo	1971		45,200	45,200
Webbers Falls, Okla	1973		60,000	60,000
West Point, Ga	1973		72,000	107,000
Total, scheduled installation			5,724,200	8,844,200
Total, in operation (table 11)		9,431,900	323,500	11,851,400
Total		9,431,900	6,047,700	20,695,600
Total in operation and scheduled installation		15,479,600		

and construction dredging, 22,642,000 cubic yards. Work continued on ten additional project features, as shown in table 15.

During the year, work was initiated on 19 features of the project, as shown in table 16, and preconstruction planning continued on Mississippi River levee enlargement, bank protection, and alluvial levees and channel improvements under construction.

Incident to construction of the project, the features maintained and operated during the year are shown in table 17.

Floods. Mid-February heavy rain, accompanied by snow melt

Table 13. Project Features Fully Completed During the Fiscal Year

Project feature	*Date completed*	*Nature of project feature*
Lake Pontchartrain, La	Aug. 1965	Flood protection.
Tensas Basin, Ark	Nov. 1965	Canal 19 extension—channel enlargement, mile 50.2–mile 59.8.
Do	Apr. 1966	Big and Colewa Creeks—enlargement Interstate 20 bridge crossing.
Do	June 1966	Bayou Lafourche—enlargement Interstate 20 bridge crossing.
Yazoo Basin Headwater, Miss		Yazoo River levees—Wasp Lake to Marksville (8.0 miles).
Do	Oct. 1965	Upper Tchula Lake levee closure, 0.3 mile.
Do	Nov. 1965	Hillside Floodway levees, Items 1, 2, and 3 (8.3 miles).
Do	Nov 1965	I.C.R.R. embankment and culvert (Hillside Floodway).
Yazoo Basin—Big Sunflower River	Aug. 1965	Dowling Bayou channel improvement (3.5 miles clearing and snagging, 4.4. miles cleanout).
Do	Aug. 1965	Ditchlow—Twin Lake Bayous Channel improvement.
Do	Nov. 1965	Big Sunflower River above Clarksdale and Mill Creek channel improvement. (11.1 miles clearing and snagging—Big Sunflower River: 7.8 miles cleanout—Mill Creek).
Wolf River and tributaries	Dec. 1965	Railroad bridge.
Yazoo Basin—Yazoo Backwater	Nov. 1965	Steele Bayou—Deer Creek, Levee Item 6 (1.8 Miles).

Table 14. Project Features Placed in Useful Operation This Fiscal Year

Project feature	*Date started*	*Date placed in useful operation*	*Nature of project feature*
Atchafalaya Basin, La	Aug. 1957	July 1965	Relocation of U.S. Highway 190 over West Atchafalaya Floodway.

Table 15. Project Features on Which Construction Continued This Fiscal Year

Project feature	*Nature of project feature*
Atchafalaya Basin, La	Levees, revetments, channel improvement by dredging and highway relocation.
Lower Arkansas River, Ark	Levee berms and bank stabilization.
Lower Red River, La	Bank protection.
Memphis Harbor, Tenn	Levee, pumping station and dredging.
Mississippi River	Levees, berms, revetments, dikes, wavewash protection and dredging.
Old River Control, La	Bank protection.
St. Francis Basin, Ark. & Mo	Floodways, channels, interior drainage, levees, highway and railroad bridges.
Tensas Basin, Ark. and La	Channel improvements and levees.
West Tennessee tributaries, Tenn	Channels, highway and railroad bridges.
Yazoo Basin, Miss	Levees and channel improvements.

Table 16. Project Features on Which Work was Initiated This Fiscal Yeai

Project feature	*Date initiated*	*Nature of project feature*
Tensas Basin, Ark	July 1965	State Highway 24 relocation, items 1 and 3 and 1 bridge, item 2.
Do	July 1965	Levee—Jonesville, La. to Diversion Channel, item 1 (4 miles along Black River).
Do	Nov. 1965	Levee and Diversion Channel—Black River to Catahoula Lake, Reach 1 (5 miles).
Do	Dec. 1965	Big and Colewa Creeks—channel enlargement, vicinity of Interstate 20 bridge.
Do	Dec. 1965	Bayou Lafourche—channel enlargement vicinity of Interstate 20 bridge.
Yazoo Basin, Miss:		
Headwater	Aug. 1965	Upper Tchula Lake Levee closure.
Do	Sept. 1965	I.C.R.R. embankment, Gwin to Durant.
Do	May 1966	Philipp Cutoff—Installation of Flap Gate in Drop Structure.
Do	May 1966	1 Holmes County Road—Hillside Floodway.
Do	June 1966	Panola-Quitman Floodway levee, item A.
Sunflower River	Sept. 1965	Dowling Bayou, Alteration 1 bridge, Sharkey Co.
Do	July 1965	Steele Bayou (9.9 miles channel enlargement; 0.5 miles clearing and snagging).
Do	Mar. 1966	Quiver River Channel Extension (mile 71.22—81.13).

Table 16. Project features on Which Work was Initiated This Fiscal Year—Continued

Project feature	*Date initiated*	*Nature of project feature*
Do	May 1966	Gin and Muddy Bayous, 2 bridges and 2 culverts, Leflore Co.
Do	May 1966	Low Water Weir (mile 61.3).
Yazoo Backwater	Aug. 1965	Levee and connecting channel—Sta. 494+66–585+86.
Do	July 1965	Steele Bayou Drainage Structure (Floodgate).
Do	June 1966	Sharkey County Bridge, item 16.
Do	July 1965	I.C.R.R. Bridge, Steele Bayou to Deer Creek, item 7.

Table 17. Project Features on Which Maintenance and Operation Activities Were, Conducted This Fiscal Year

Project feature	*Nature of project feature*
Mississippi River	Levees, revetments, dikes, wavewash protection, and dredging.
Atchafalaya Basin, La	Maintenance of levees and channels Operation and maintenance: Locks: Bayou Boeuf, Bayou Sorrel, and Berwick Floodgates: Bayou Courtableau, Calumet and Charenton Drainage stuctures: Wax Lake Outlet and numerous small structures
Bonnet Carre Spillway, La	Levees, floodway, and control structure
Lower Arkansas River, Ark	Levees, revetments, and dikes
Lower Red River, La	Bank protection works
Lower White River, Ark	White River backwater pumping plant
Memphis Harbor	Levees and dredging
Morganza Floodway, La	Floodway and control structure
Old River Control, La	Maintenance of levees, channels, and bank protection Operation and maintenance: Navigation lock Control structures: Low sill and overbank
St. Francis Basin, Mo.:	
Wappapello Reservoir	Reservoir
Tensas Basin, La	Bayou Cocodrie drainage structure
Yazoo Basin, Miss.:	
Yazoo Headwater	Levees and channels
Greenwood	Local protection levees, storm water pumping station, and drainage structures
Yazoo City	Do.
Sardis Reservoir	Reservoir
Arkabutla Reservoir	Do.
Enid Reservoir	Do.
Grenada Reservoir	Do.

in the Ohio, lower Missouri, and middle Mississippi River basins, produced crest stages at Cairo, Ill., and Memphis, Tenn. of 41.9 and 27.6 feet, respectively. These stages were about two feet below flood stage at Cairo and about six feet below flood stage at Memphis. Crest stages on the Mississippi River at other stations ranged about 14 feet below flood stage at Arkansas City, Ark. to about two feet below at Red River Landing and New Orleans, La.

Red River crested at Alexandria, La., at a stage of 35.45 feet, about two feet above flood stage. Crest stages on the Ouachita River occurred in April 1966 and were 8 and 13 feet above flood stage at Arkadelphia and Camden, Ark., respectively. Operation of Blakely Mountain Reservoir reduced the crest stage at Arkadelphia by an estimated two feet. Operation of Blakely and Narrows Reservoirs reduced crest stage at Camden by an estimated 1.5 feet.

Principal rises on Yazoo-Tallahatchie-Coldwater Rivers occurred in February and produced crest stages slightly above flood stage at Swan Lake, Mississippi, four feet below flood stage at Greenwood, and about one foot above flood stage at Yazoo, City, Miss. Operation of flood control works effected stage reductions averaging about five feet on Coldwater and Tallahatchie Rivers, and about 4.5 feet on the Yazoo River at Greenwood, and three feet at Yazoo City. Big Black River crested at Bovina, Mississippi, at a stage about 10 feet above flood stage.

Lower White River crested at Clarendon, Ark. in May, at a stage of 30.3 feet about seven feet above flood stage. This crest was materially reduced by operation of upstream reservoirs.

The St. Francis River crested at St. Francis, Ark., in May at a stage of 21.9 feet, about three feet above flood stage. Operation of flood control works effected stage reductions above St. Francis, Ark. ranging from one to two feet.

Crest stages occured in February on the West Tennessee tributaries as follows: Loosahatchie River at Brunswick, 23.2 feet, 2.0 feet above flood stage; North Fork, Forked Deer River at Dyersburg, 24.3 feet, 10 feet above flood stage; Obion River at Bogota, 17.9 feet, five feet above flood stage. Wolf River crested at Raleigh at 7.7 feet, about four feet below flood stage. Hatchie River crested at Rialto at 15.3 feet about three feet above flood stage.

Condition of overall project. At the end of the fiscal year, construction on the project as a whole between Cape Girardeau, Mo., and the Gulf of Mexico was sufficiently well advanced to afford a high degree of protection from Mississippi River flood over-

flow to most of the alluvial valley, except in unprotected backwater areas. A total of 1,732 miles of main line levees has been authorized, of which 1,725 miles have been built. Of the levees built 1,607 miles are to approved grade and section. Of the authorized main line levees, 1,572 miles are along the Mississippi River, and the remainder along major tributaries (lower Arkansas and Red Rivers). Of the levees built to approved grade and section 1,460 miles are along the Mississippi River. The bank stabilization program has progressed steadily during recent years through construction of bank revetments, dikes and corrective dredging to prevent the river from regaining its former length due to its natural tendency to meander. A long-range plan is being developed to bring about and maintain the desired alignment of the river between Baton Rouge, La., and Cairo, Ill.

At the end of the fiscal year, there were 550 miles of operative revetments and 314,000 linear feet of effective dikes on the Mississippi River below Cairo, Ill.; channel stabilization work on the Arkansas River adjacent to the project levee consists of 65 miles of revetment and 204,000 linear feet of dikes. Stabilization work on Lower Red River and Atchafalaya River consists of 8.4 miles of revetment and 15,800 linear feet of dikes.

The Arkabutla, Sardis, Enid, and Grenada Reservoirs in the Yazoo Basin, Miss., and the Wappapello Reservoir in the St. Francis Basin, Mo., have been completed. Other authorized improvements in the alluvial valley including levees, channel improvement, and supplementary drainage works, are under construction. The Bonnet Carre, Morganza, and West Atchafalaya Floodways are in a useful operational status, and with the Atchafalaya River will permit the diversion of 1,750,000 cubic feet per second of the project flood discharge to the Gulf of Mexico, leaving 1,250,000 cubic feet per second to pass down the main stem at New Orleans, La. Old River navigation lock, low sill, overbank structures with appurtenant entrance and exit channels, and the highway bridge over the lock, have been completed and are in operation. Work to be accomplished consists of some additional revetment. The Old River control project will prevent steadily enlarging channels of the Old and Atchafalaya Rivers from capturing the flow of the Mississippi River. The total benefits that have accrued since adoption of the project are estimated at about $8 billion, which amounts to approximately $6 in benefits for every dollar of project funds thus far expended.

The authorized Mississippi River and tributaries project, as

DISABLING INJURY FREQUENCY AND SEVERITY RATES

FREQUENCY RATE : DISABLING INJURIES PER MILLION MANHOURS OF EXPOSURE
SEVERITY RATE : DAYS LOST PER THOUSAND MANHOURS OF EXPOSURE

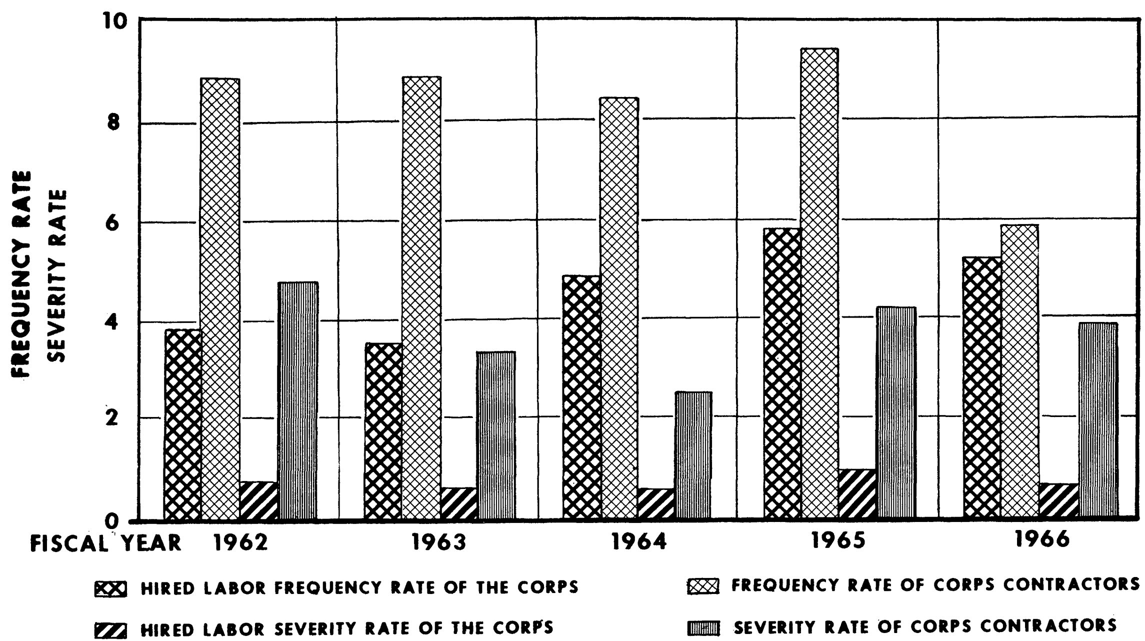

CHART III

amended, provides for a 12 - by 300 - foot navigation channel in the Mississippi River between Baton Rouge, La., and Cairo, Ill., and a 12 - by 125 - foot channel in Old and Atchafalaya Rivers between the Mississippi River and Morgan City, La. The Mississippi River channel was maintained between Baton Rouge and Cairo to provide a dependable 9-foot depth for navigation except at Kentucky Point, Ky., (mile 887 AHP) August 5–6, 1965, when the controlling depth was 8.5 feet. Commensurably greater depths were available during the high-water season. The Atchafalaya River channel through Grand and Six Mile Lakes between the Mississippi River and Morgan City, La., was maintained to provide adequate depth throughout the year.

6. OPERATIONS (GENERAL)

Work done by contract. The Corps consistently adheres to the policy of having construction work done by contractors wherever practicable. The hired labor work on construction projects has been limited to such types of operations as dredging in exposed harbor entrances by government-owned hopper dredges, the construction of erosion-control and levee-revetment works, and grouting operations. The nature of such work does not readily lend itself to advertising and performance by contract.

Accident prevention. Injury rates, both frequency and severity, for Government and contractor employees show improvement over those for fiscal year 1965 and are below the National averages. The amount of damage to property and equipment was 40 percent lower than that for fiscal year 1965.

Fire prevention. There were only six incidents which resulted in losses of $8,042 to Government property and equipment. This is a decrease of 38 percent over the losses for fiscal year 1965.

CHAPTER VI

FUNDING

1. FUNDS AVAILABLE

Fiscal year 1966 funds appropriated for civil works activities of the Corps amounted to $1,329,961,739. Individual appropriations are detailed in table 18. Status of funds advanced by local interests for navigation and flood control improvements is shown in table 19.

Table 18. Appropriations, Fiscal Year 1966

The funds with which the works for the maintenance and improvement of rivers an d harbors and flood control were prosecuted during the fiscal year were derived from un - expended balances of prior appropriations and from the following appropriations acts, and by transfer from other departments:

Appropriation title	*Date of act*	*Amount*
JOINT RESOLUTION:	June 30, 1965	
Flood control, Mississippi River and tributaries		$7,700,000
General investigations, Corps of Engineers, Civil		2,000,000
Construction, general, Corps of Engineers Civil		78,000,000
Operation and Maintenance, general, Corps of Engineers, Civil		17,500,000
Flood Control, Hurricane & Shore Protection Emergencies, Corps of Engineers, Civil		5,000,000
General expenses, Corps of Engineers, Civil 1966		1,000,000
Total		111,200,000
PUBLIC WORKS APPROPRIATION ACT, 1966	Nov. 3, 1965	
Flood control, Mississippi River and tributaries		77,242,500
General investigations, Corps of Engineers, Civil		23,435,000
Construction, general, Corps of Engineers, Civil		915,279,000

Table 18. Appropriations, Fiscal Year 1966—Continued

Appropriation title	*Date of act*	*Amount*
Operation and maintenance, general, Corps of Engineers, Civil		158,262,000
General expenses, Corps of Engineers, Civil, 1966		15,537,000
Flood Control, hurricane and shore protection emergencies, Corps of Engineers, Civil		7,000,000
Total		1,196,755,500
SUPPLEMENTAL APPROPRIATION ACT, 1966:	Oct. 31, 1965	
General investigations, Corps of Engineers, Civil, 1966		30,000
SUPPLEMENTAL APPROPRIATION ACT, 1966:	Oct. 31, 1965	
Construction, general, Corps of Engineers, Civil, 1966		900,000
SECOND SUPPLEMENTAL APPROPRIATION ACT, 1966:	May 13, 1966	
Operation and maintenance, general, Corps of Engineers, Civil		7,350,000
Flood control, hurricane and shore protection emergencies, Corps of Engineers, Civil		7,750,000
General expenses, Corps of Engineers, Civil 1966		385,000
Total		15,485,000
SPECIAL FUNDS:	Treasury Warrant No.	
Hydraulic mining in California, debris fund	681–96–5	18,000
Payments to States, Flood Control Act, June 28, 1938, as amended	1106–96–8	2,421,562
Maintenance and operation of dams and other improvements to navigable waters (credits to accounts from licenses under Federal Water Power Act of 1935)	1078–96–7	3,151,676
Total		5,591,238
TRUST FUNDS (CONTRIBUTIONS AND ADVANCES):		
Rivers and Harbors contributed funds	Various	24,872,087
Rivers and Harbors advances funds	do	636,000
Total		25,508,087

Table 18. Appropriations, Fiscal Year 1966—Continued

Appropriation title	*Date of act*	*Amount*
FUNDS TRANSFERRED FROM OTHER DEPARTMENTS:		
Consolidated working fund, Army, Engineers, Civil		285,000
Consolidated working fund, Army, Engineers, Civil, 1965		*−1,900
Consolidated working fund, Army, Engineers, Civil, 1966		23,000
Consolidated working fund, Army, Engineers, Civil, 1956–1967		500
Construction International Boundary & Water Commission, U.S. & Mexico, State (transfer to Corps of Engineers, Civil)		125,000
Contributions, Educational and Cultural Exchange, State (transfer to Corps of Engineers, Civil)		1,100
Land and Water Conservation, Bureau of Outdoor Recreation, Interior (transfer to Corps of Engineers, Civil)		250,000
Capital outlay, U.S. Soldier's Home (transfer to Corps of Engineers, Civil)		82,428
General investigations, Bureau of Reclamation (transfer to Corps of Engineers, Civil)		15,000
Natural disaster study, Office of Administrator, HHFA (transfer to Corps of Engineers, Civil)		280,000
Construction, Bureau of Indian Affairs, Interior (transfer to Corps of Engineers, Civil)		*−25,444
Total		1,034,684
Grand total, all funds		1,356,504,509

* Returned to originating agency.

2. APPROPRIATIONS

Chart IV indicates the fluctuation in annual appropriations since 1956 for civil works functions.

3. EXPENDITURES (COSTS)

During the fiscal year expenditures (costs) were $1,286,650,763 on the Civil Works Program. Of this amount, $1,036,036,853 was

ACTUAL APPROPRIATIONS CIVIL WORKS FUNCTIONS

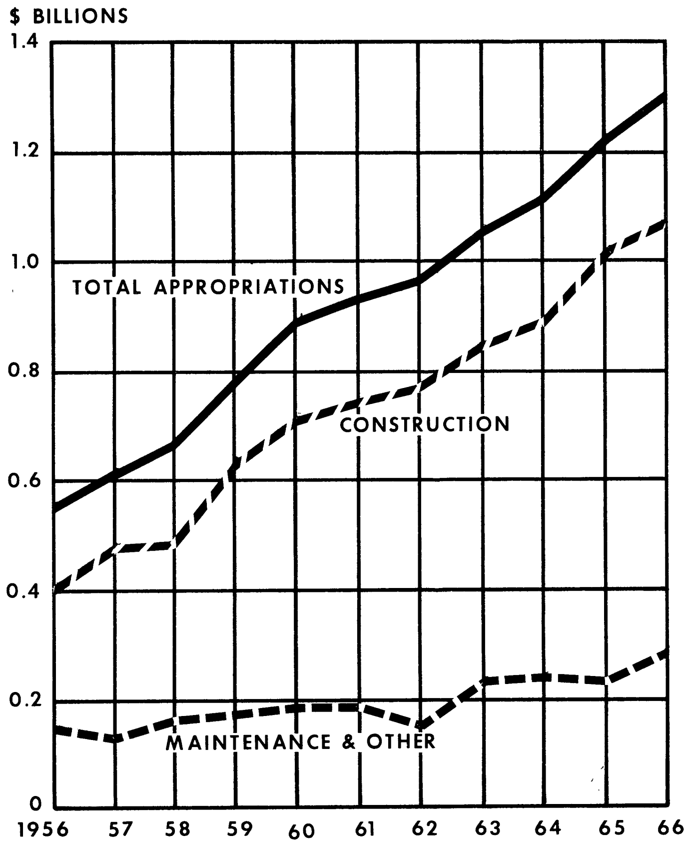

CHART IV

EXPENDITURES (COST)
CIVIL WORKS FUNCTIONS

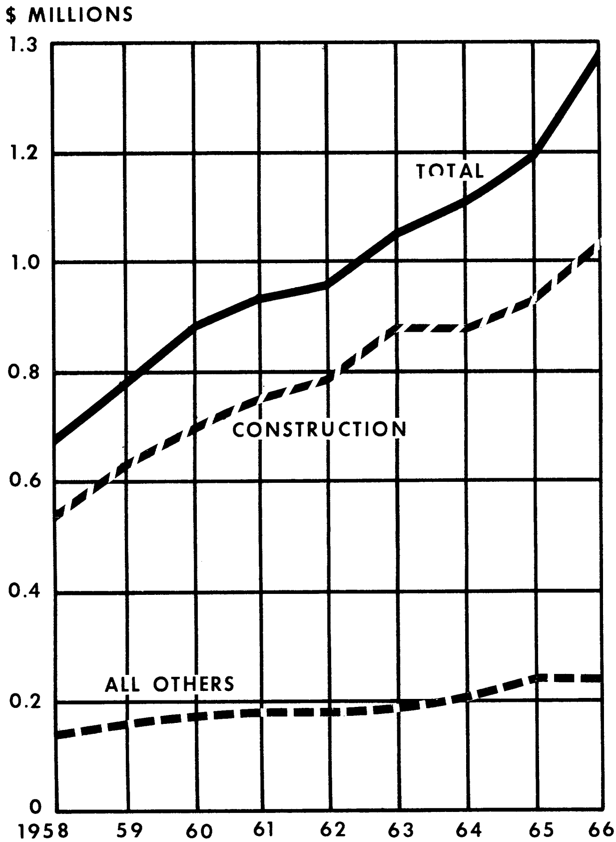

CHART V

Table 19. Advanced Funds, Fiscal Year 1966

The following amounts have been advanced by local interests for river and harbor improvements under the provisions of section II, River and Harbor Act of 1925, and for flood control works under the provisions of the act of October 15, 1940, and are returnable to the same interests when necessary Government funds are available.

District	Balance due from United States, June 30, 1965	Amount received during fiscal year	Amount returned during fiscal year	Balance due from U.S. June 30, 1966
Anaheim Bay Harbor, Los Angeles Calif	$1,447,000			$1,447,000
Cabrillo Beach, Calif do	143,400			143,400
Doheny Beach, Calif do	116,780	$636,000		752,780
Imperial Beach, Calif do	29,399			29,399
Redondo Beach, Calif do	50,000			50,000
Ventura-Pierpont, Calif do	332,857			332,857
Total rivers and harbors	2,119,436	636,000		2,755,436

for construction and $250,613,910 for all other activities except those funded by contingencies, advances, and collections from local sources and transfers from other agencies. Chart V shows comparative expenditure (cost) data since 1958. Expenditures under each appropriation are listed in table 20.

Table 20. Accrued Expenditures, Fiscal Year 1966

The total actually expended under the direction of the Chief of Engineers in connection with the maintenance and improvement of rivers and harbors, flood control, and other miscellaneous works during the fiscal year as follows:

Appropriation title	Amount
RIVERS AND HARBORS AND FLOOD CONTROL:	
Flood control, Mississippi River and tributaries	$87,682,716
General investigations, Corps of Engineers, Civil	24,666,754
General investigations, Corps of Engineers, Civil, 1966	6,291
Construction, general, Corps of Engineers, Civil	971,344,834
Construction, general, Corps of Engineers, Civil, 1966	530,789
Operation and maintenance, general, Corps of Engineers, Civil	174,985,405
General expenses, Corps of Engineers, Civil, 1964	−23
General expenses, Corps of Engineers, Civil, 1965	84,285
General expenses, Corps of Engineers, Civil, 1966	16,766,265
Flood Control, hurricane & shore protection emergencies, Corps of Engineers, Civil	19,763,018

Table 20. Accrued Expenditures, Fiscal Year 1966—Continued

Appropriation title	*Amount*
Maintenance & operation of dams and other improvements of navigable waters	153,727
Total rivers and harbors and flood control	1,295,984,061
MISCELLANEOUS APPROPRIATIONS:	
Hydraulic mining in California, Civil	19,209
Payments to States, Flood Control Act of 1938, as amended	1,959,307
Total miscellaneous appropriations	1,978,516
CONTRIBUTED AND ADVANCED FUNDS:	
Rivers and harbors, contributed funds	22,949,298
Rivers and harbors, advanced funds	−929,933
Total contributed and advanced funds	22,019,365
Total appropriated and contributed funds	1,319,981,942
TRANSFERS FROM OTHER DEPARTMENTS:	
Capital outlay, U.S. Soldiers' Home (transfer to Corps of Engineers, Civil)	$43,847
Consolidated working fund, Army, Engineers, Civil	3,966
Consolidated working fund, Army, Engineers, Civil, 1966	1,670
Consolidated working fund, Army, Engineers, Civil, 1956–1967	368
Construction, International Boundary and Water Commission, U.S. and Mexico, State (transfer to Corps of Engineers, Civil)	80,728
Contributions, Educational & Cultural Exchange, State (transfer to Corps of Engineers, Civil)	664
General investigations, Bureau of Reclamation (transfer to Corps of Engineers, Civil)	7,493
Highway trust fund, Treasury (transfer to Corps of Engineers, Civil)	19,735
Land and water conservation, Bureau of Outdoor Recreation, Interior (transfer to Corps of Engineers, Civil)	132,788
Natural disaster study, Office of the Administrator, HHFA (transfer to Corps of Engineers, Civil)	207,380
Public Works Acceleration, Executive (transfer to Corps of Engineers, Civil), 1963	25,272
U.S. dollar advances from Foreign Governments, U.S. Educational Exchange Program, State (transfer to Corps of Engineers, Civil)	554
Total transfers from other departments	524,465
Grand total, all funds	1,320,506,407

CHAPTER VII

ECONOMY MEASURES

The program to reduce costs, improve operations, and increase productivity was continued during fiscal year 1966 to provide economies in Corps activities. Typical examples of the savings accomplished under the cost reduction programs are cited below:

Engineering and construction. The design of the penstock emergency gates at Dworshak Dam and Reservoir was changed from the fixed wheel type to the caterpillar type. Because of the high operating heads at this location, large wheels and heavy gate frames would have been required for the fixed wheel units. The greater number of rollers on the caterpillar design permitted the use of lighter gate frames along with an overall one time saving of $214,000 at this installation.

Original plans for the construction of locks and dams 2, 4, and 6 on the Arkansas River called for white bearing metal, at a cost of $1.40 per pound as a filler material behind miter gate contact blocks and also under tainter valve seals. By substituting zinc, at a cost of $0.145 per pound, for the white bearing metal, a total saving of $77,953 was realized on the three above locks and at four additional installations.

Upon completion of the excavation for the approach channel to the Racine locks in the Huntington District, it became evident that bank protection, not provided for in construction plans, would be necessary to maintain bank stability. As rock was concurrently being excavated from the lock area the Resident Engineer arranged to have this material dumped, at no cost to the government, along the downstream bank resulting in a one time cost avoidance of $190,843.

Floating plant operation. Two shallow draft sidecasting dredges were constructed to operate in areas too shallow for hopper dredge activity and too rough for pipeline dredges. Surplus Navy vessels were utilized in this construction. The dredge *MERRITT* was built on a 104-foot YSD hull at a saving of $350,000 over new construction costs and the dredge *SCHWEIZER* was built on a 133 foot YF hull at a saving of $500,000 over the cost of a similar

new dredge. Besides the initial construction cost saving, these dredges are now accomplishing work that either could not be accomplished by previously existing plant or which would have been economically unfeasible because of high mobilization and lost time charges.

Supply. A continuing program for locating and utilizing items of engineer and construction equipment available as surplus from other Federal agencies has greatly reduced capital outlay for civil works. During fiscal year 1966, this program resulted in the acquisition of equipment valued at approximately $4,000,000.

Value engineering. The value engineering program activity continued during fiscal year 1966. This program invites suggestions from contractors as to means of reducing construction costs without impairing the efficiency or integrity of the structures. During this fiscal year, a total of 79 value engineering proposals were received from our construction contractors. Thirty-one of these ideas were accepted, resulting in net savings to the Government of $112,207.

Employee suggestions. Employee suggestions through the Incentive Awards Program provided a substantial share of the improvement projects completed throughout the Corps of Engineers. In fiscal year 1966 over 3,000 suggestions were adopted. Those applicable to civil works produced savings in excess of $1.6 million.

Automatic data processing. The Corps has continued to increase the use of automatic data processing equipment (ADPE). Through improved methods and expanded ADP capability, greater benefits have been achieved. The Districts have been able to handle the increasing workload without comparable increases in the engineering staffs. In addition, the use of ADPE has permitted more flexible analyses, greater accuracy and reduced response time, particularly in applications such as design problems. Time-consuming, tedious, repetitious computations are eliminated through more efficient ADPE and engineers enabled to perform more professional tasks.

CHAPTER VIII

WATERBORNE COMMERCE

In 1965, U.S. waterborne commerce advanced for the fourth consecutive year to reach a record total of 1,273 million tons and 262 billion ton-miles.

New highs were recorded in both the foreign and the domestic trades. Foreign traffic showed the greatest gain over 1964 with an increase of 22 million tons to 444 million tons. Domestic traffic rose from 816 million tons to 829 million tons.

In the foreign trade, imports increased by 21.2 million tons, and exports increased 0.6 million tons over the tonnages of these traffics in 1964. Tonnage moved directly between U.S. Great Lakes ports and overseas ports via the St. Lawrence Seaway gained sharply from 7.6 million tons to almost 10 million tons.

In the domestic trades, internal traffic increased 11.7 million tons to a new high of 369.6 million tons; and Great Lakes, lakewise traffic increased 2.3 million tons to 153.7 million tons. Coastwise traffic declined 4.2 million tons to 201.5 million tons. Local traffic tonnage increased by 3.3 million tons to 102.9 million tons; intraterritory traffic declined 0.1 million tons to 1.5 million tons.

Ton-miles of freight carried in 1965 on the inland waterways, including the Great Lakes, reached a new high of 262 billion, a gain of 12 billion over the total for 1964. Ton-miles of carriage on waterways other than the Great Lakes increased by 8 billion to 152 billion, and ton-miles on the Great Lakes rose 4 billion to 110 billion. The Mississippi River System again established a new high of 97 billion ton-miles in 1965, an increase of 8 billion ton-miles over 1964. All other systems carried 55 billion ton-miles in 1965, unchanged from the amount carried in 1964.

Total freight handled at ports and carried on the waterways improved by the Corps of Engineers under Congressional authorization are presented in the following tabulations. Detailed data on the commodities handled and the vessel trips at individual ports and waterways are in the publications listed in paragraph B2, section 10, chapter IX.

TOTAL WATERBORNE COMMERCE OF THE UNITED STATES 1956-1965

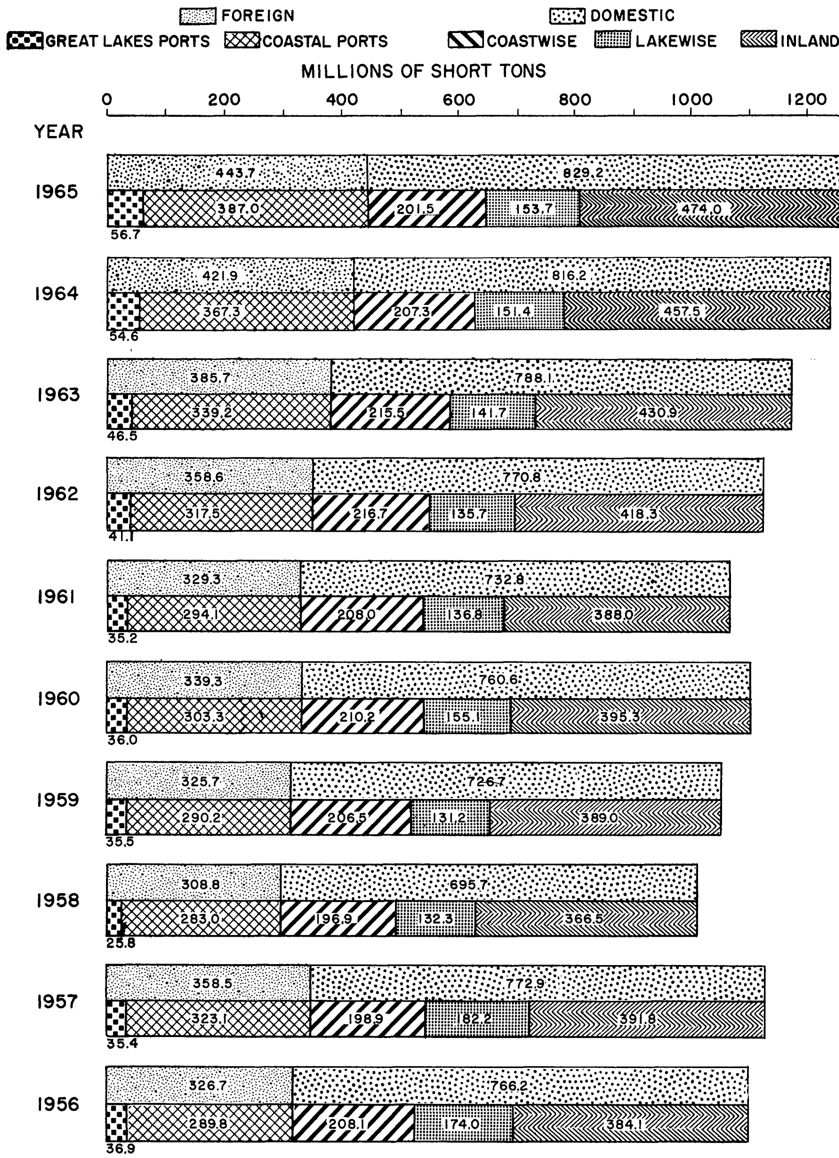

CHART VI

TON-MILES OF FREIGHT CARRIED ON THE WATERWAYS OF THE UNITED STATES, 1956-1965

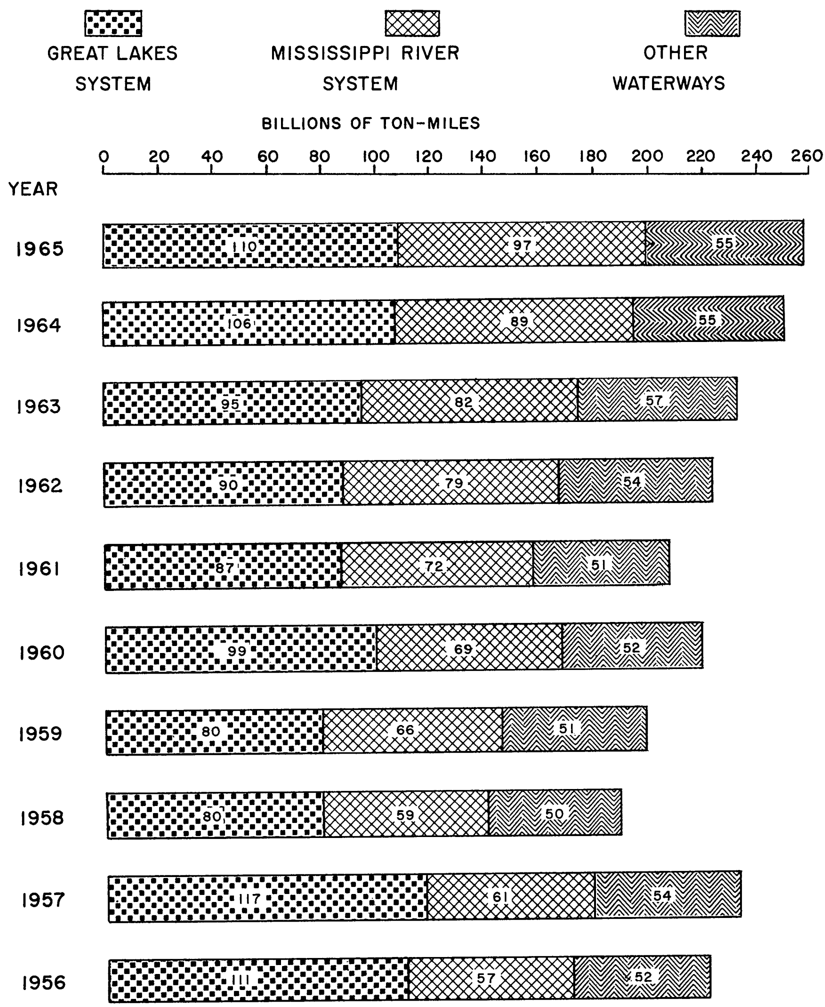

CHART VII

CHAPTER IX

OTHER ACTIVITIES

1. FLOOD FIGHTING AND OTHER EMERGENCY OPERATIONS

Emergency flood control and shore protection activities were carried on during the year pursuant to statutory authority set forth in Public Law 99, 84th Congress, as amended by section 206, Flood Control Act of 1962. Public Law 99 activities include: advance preparation for flood emergencies; flood fighting and rescue work; and the repair and restoration of flood control works damaged by flood, and of Federally authorized shore protection works damaged by storm. Fiscal year expenditures from the emergency fund totaled $19,763,018. Disaster assistance beyond the scope of Public Law 99, primarily engineering and construction services, was provided as authorized and directed by the Office of Emergency Planning (OEP), acting on behalf of the President, in accordance with procedures established pursuant to Public Law 875, 81st Congress (Federal Disaster Act of 1950). Also, emergency work was undertaken as requested by other Federal agencies on a reimbursable basis. The most noteworthy emergency operations during the fiscal year are described in folowing paragraphs.

Alaska Earthquake Disaster, March 1964. The program of OEP-requested disaster assistance under Public Law 875, estimated to cost $55 million, has been essentially completed. Navigation facilities are being reconstructed under statutory authorities of the Corps, at $3.7 million estimated cost. Work completed or underway totals $3.3 million. The rebuilding of the Alaska Railroad facilities at Seward for the Department of Interior, costing $10.8 million, is substantially complete. Reconstruction work being done for the Alaska State Housing Authority under an Urban Renewal program is scheduled for completion in 1967. Of this $11.6 million program, $7 million of work has been completed or is underway.

Western States Floods, December 1964 and January 1965. The Public Law 875 disaster assistance program requested by the OEP

in Oregon, Washington, California, and Idaho following the disastrous floods of December 1962 and January 1965, estimated to cost $23.5 million, is substantially completed. The program of emergency assistance provided by the Corps under Public Law 99 has been completed, at $10.7 million cost.

Upper Mississippi River Floods, April-May 1965. The Public Law 875 disaster assistance program requested by the OEP in Illinois, Iowa, Wisconsin, and Missouri has been completed at $500,000 cost. Repair and rehabilitation of flood control works, under Public Law 99 authority, was accomplished at a cost of $2.2 million.

Colorado–Kansas Floods, June 1965. The Public Law 875 disaster assistance program requested by the OEP in the South Platte and Upper Arkansas River basins, and estimated to cost $860,000, has been completed. Under the Corps Public Law 99 authority, a program of repair and restoration of damaged flood control works has been completed, at a cost of $810,000.

Hurricane Betsy, Sept. 9–10, 1965. In early September 1965, Hurricane Betsy crossed southern Florida, headed across the Gulf of Mexico, and struck northward into Louisiana and Mississippi. There was considerable shore damage on Florida's east coast, appreciable damage in Mississippi, and catastrophic damage in Louisiana. The President declared the affected portions of Florida, Louisiana, and Mississippi to be major disaster areas. Army Engineers fought the floodwaters, closed breached levees in the New Orleans area, performed flood rescue work, and provided technical advice and assistance. The Corps of Engineers has substantially completed the OEP-requested disaster assistance program under Public Law 875 in Louisiana and Mississippi, estimated to cost about $39 million, including reimbursement of $25 million to local interests for eligible work. Included in that program was the recovery of the chlorine-laden barge MTC 602, sunk during the hurricane in the vicinity of Baton Rouge, La. Rehabilitation of flood control works under Public Law 99 authority at estimated cost of $4.8 million and recovery of Corps-maintained navigation projects and facilities at estimated cost of $2.6 million are about 65 percent complete.

Southern California Floods, November and December 1965. Torrential rains in late November and early December 1965 triggered floods in southern California, declared by the President to be a "major disaster." Under Public Law 99 authority, the Corps performed emergency work on Tahquitz Creek, opening

a debris-plugged channel and reinforcing protective levees in the city of Palm Springs. Disaster assistance requested by the OEP under Public Law 875 authority is underway in San Bernardino County, Calif. at a cost of about $300,000. Corps projects within the flood area prevented substantial damage.

Flood Emergency at Smuggler's Gulch, Tijuana, Mexico, December 1965. Impoundment of floodwaters because of inadequate outlets threatened failure of a highway fill across Smuggler's Gulch with resultant flooding of the Tijuana River area in San Diego County, Calif. Under the authority of Public Law 99, and at the request of the International Boundary and Water Commission in coordination with the Mexican Government, the Corps provided the necessary pumps and drew down the pool to a safe level. This emergency operation cost $208,066 over a period of about 30 days.

Ice Jam Flooding, Upper Mississippi River, February 1966. A period of severe cold weather, followed by ice melt from unseasonal warm temperatures, caused ice jams and floods in the upper Mississippi River and tributaries, particularly in the Quad-Cities area. The Corps advised the affected communities on protective measures, and provided assistance to supplement local resources. Low-land flooding on the Mississippi in the area of Davenport, Iowa, was caused by a massive ice gorge up to ten miles long. The Corps emergency operations to reduce the ice jamming included aerial dusting of the ice with calcium chloride and coal dust, to hasten melting, and then use of barge tows as ice breakers. In early March, two barge tows engaged under Corps contact broke the ice jam and relieved the flooding. Flood damages were estimated to total $1 million.

Spring Floods, Upper Mississippi and Red River of the North River Basins, March-April 1966. A severe blizzard in early March, preceded by very cold weather and deep frost penetration, created a dangerous flood potential in the Red River of the North and Upper Mississippi River basins. The Corps promptly undertook protective measures. Corps personnel advised communities likely to be affected by floods regarding the magnitude of the flood threat and possible emergency protection measures. Many communities were provided technical and other assistance by the Corps in the construction of temporary dikes and other emergency flood protection works. The occurrence of high temperatures and rapid snow melt caused general flooding, with the Red River of the North reaching the highest stage of this century. In Minn-

esota and North Dakota, consequent flooding of over a million acres of farmland, and of a few urban areas, caused damages approximately $12 million. However, over $5 million of additional damage would have occurred had it not been for the success of the flood fighting operations conducted by local interests before and during the flooding with assistance provided by the Corps and other Federal agencies. The cost of Corps emergency operations is currently estimated at $160,000. A "major disaster" declaration by the President under Public Law 875 covered 22 counties in Minnesota and 16 counties in North Dakota. Disaster assistance provided by the Corps as requested by the OEP, under Public Law 875, is substantially completed at the cost of about $1 million.

Texas Floods, April-May 1966. Heavy rains in northeastern Texas caused severe flooding in the Trinity, Sabine, and Brazos River basins. Flood damage, including extensive property damage in the Dallas area, was estimated at $17.8 million. Completed Corps projects prevented another $52 million in damages in the Trinity River basin, and about $18.5 million of damages were prevented in the Brazos River basin.

Kansas Tornadoes, June 1966. Disastrous tornadoes struck eastern Kansas, principally affecting Shawnee and Riley Counties, on June 6, 1966. Damages totaled more than $73 million, according to preliminary estimates. The President made a "major disaster" declaration covering the affected areas on June 10, 1966. The OEP requested assistance from the Corps under Public Law 875 authority, in making damage surveys; and further by accomplishing debris removal and preparing trailer-park sites for emergency housing. The cost of this Public Law 875 work is estimated at $1,025,000.

Northeastern Drought. At the request of the Federal Water Resources Council, the Corps completed a survey of the Northeastern States affected by the severe drought. The survey covered available community water supplies, and identified communities having critical water supply problems. Additionally, requested technical assistance was provided to communities in the solution of water supply problems; an inventory of water supply equipment available for emergency use was compiled; and some Corps flood control projects were effectively operated to alleviate stream flow deficiencies. The President made a "major disaster" declaration covering drought effects in the Delaware River Basin service area. The Corps, at OEP request under Public Law 875,

then assisted the city of Philadelphia in accelerating the modification of their Torresdale water inlet on the Delaware River; and supplemented the water supply available in Hudson and Bergen Counties, N. J. The latter operation involved construction and operation of a temporary pipeline which diverted 3.7 billion gallons of water from Lake Hopatcong to the Boonton Reservoir, N.J.

2. PROTECTION OF NAVIGABLE WATERS

In administering the Federal laws enacted for the protection and preservation of navigable waters of the United States, 6,897 permits were granted for structures or other work in navigable waters, and plans for 150 bridges, dams, dikes, or causeways were approved during the year. In addition, 97 extensions of time for commencement or completion of construction of bridges were granted. Thirty-six sets of regulations were promulgated establishing and governing the use, administration, and navigation of anchorage ground, special anchorage areas, and danger zones. Twenty-seven sets of regulations were prescribed to govern the operation of drawbridges across navigable waters.

The Corps engaged in the following additional activities relative to the administration of the laws for the protection of navigable waters: investigations of the discharge or deposit of refuse matter of any kind in navigable waters; prevention of pollution of coastal navigable waters by oil; administrative determination of the heads of navigation and the extent to which the laws shall apply to specific streams; supervision of the harbors of New York, Hampton Roads, and Baltimore to prevent obstructive and injurious deposits in the waters thereof, including the waters of Long Island Sound; establishment of reasonable rates of toll for transit across bridges over navigable waters; granting of permits for the occupation and use of Federal works under control of the Corps of Engineers; report of international boards on operations affecting international boundary waters; legislation in connection with the foregoing and prevention and removal of any deposits in channels which obstruct navigation or increase Federal maintenance costs. The program has resulted not only in a saving in dredging costs and more efficient use of dredging equipment, but also in a stimulation of planning by the industries to improve their operations for recovering salvageable material. The Corps is making a thorough review of its policy on

bridge clearances with a view to resolving problems involved in meeting the requirements of both water and land transportation interests. The present system of standard bridge clearances is being reviewed and extended to cover, insofar as practicable and necessary, all navigable waterways. During the fiscal year standards for the Ohio River were modified to require a vertical clearance of 55 feet above the 2-percent line or 69 feet normal pool elevation, whichever is greater.

Under the Bridge Alteration Act (Truman-Hobbs) of June 21, 1940, as amended by the act of July 16, 1952, the cost of altering a bridge used for railroad traffic, combined railroad and highway traffic or a publicly owned highway bridge, found by the Secretary of the Army to be obstructive to navigation, is apportioned between the bridge owner and the United States. Public hearings are being held to develop data as a basis for determining if a bridge is an unreasonable obstruction to navigation. During fiscal year one hearing was held for this purpose. Funds have been made available for continuation of alteration of five bridges. Action was continued on 12 additional bridges in various stages of study.

3. HYDRAULIC MINING, CALIFORNIA

The California Debris Commission created by act of Congress, regulates hydraulic mining in the drainage area of the Sacramento and San Joaquin Rivers to prevent the resulting debris from being carried into navigable waters. The Commission currently has eight licensed mining operators, of which three utilize storage behind the Federal debris dams.

During the year the Harry I. Englebright Dam and the North Fork Dam, together with their appurtenant service facilities, were operated and maintained for the storage of hydraulic mining debris.

Maintenance work accomplished on the Yuba River during the fiscal year, by contract, consisted of bank protection, both banks, Yuba River, various locations between Hallwood Boulevard and Simpson Lane in Yuba County. The cost of this activity was paid in part by funds provided from receipts of required contributed funds.

Rehabilitation of Daguerre Point Dam, Yuba River, was completed in early December 1964, by replacing the existing wood and concrete structure with a concrete gravity dam. On December

22, 1964, the north abutment of Daguerre Point Dam, including the Hallwood-Cordua Irrigation Division structure and a portion of the fish ladder, failed under pressure of the largest flow ever experienced on the Yuba River. The reconstructed portion of the dam completed earlier in December 1964 was undamaged by the flood. Emergency minimum repair and restoration work was accomplished under Public Law 875. Permanent rehabilitation of structure was completed in October 1965, prior to the 1965–66 flood season. One-half of the cost of this project work was reimbursed by the State of California. The irrigation facilities were replaced at the expense of the Hallwood-Cordua Irrigation Districts .

4. NUCLEAR EXPLOSIVE STUDIES FOR CIVIL CONSTRUCTION

The U.S. Army Engineer Nuclear Cratering Group continued its joint program with the U.S. Atomic Energy Commission to develop the use of nuclear explosives for large-scale excavation. Project Pre-Schooner II, an 85-ton charge of nitromethene buried 71 feet in rhyolite, was executed in September 1965. The resultant crater averaged 56 feet in depth and 190 feet in diameter and was about the same size as the Danny Boy nuclear crater in basalt which was fired in 1962 at a yield of 420 tons. The results indicate that rock characteristics have a significant effect upon crater size. Pre-Schooner II was heavily instrumented by the Waterways Experiment Station and the Nevada Operations Office of the U.S. Atomic Energy Commission and its two laboratories, the Lawrence Radiation Laboratory and the Sandia Corporation. The experiment provided valuable data regarding cratering characteristics in hard, dry rock.

Plans and pre-shot investigations were completed for a series of cratering experiments in a wet clay-shale medium. The site selected for the experiment is in the Fort Peck Reservoir area, Montana, and seismic calibration experiments were conducted using 1,000 pound charges in June 1966. These will be followed by four shots of 20 tons each at varying depths in the fall of 1966.

Engineering and theoretical studies of the problems associated with the use of nuclear explosives continued during the year. The Omaha District completed a study of conventional excavation required in conjunction with nuclear explosives; the Forth Worth District prepared a report on the construction techniques and

costs of emplacing nuclear explosives; and Duke University completed part one of a series of studies on cratering mechanisms.

5. FOREIGN TECHNICAL ASSISTANCE

The Corps of Engineers continued to participate in the foreign technical assistance program of the Department of State, the Agency for International Development (AID), and the United Nations. This participation entailed the inservice training of selected engineers from foreign governments in water resources development, the detailing of technical specialists to provide assistance for civil works projects in foreign countries in support of AID programs, the accommodation of visiting foreign nationals at civil works projects and activities, and the provision of engineering information and literature relating to the development of water resources. In addition, the Corps participated throughout the year in the planning for the Water for Peace Program.

Assistance to foreign countries during the period included the following:

Country	*Description*
American Samoa	At the request of the Governor, an engineer from the Honolulu District performed a wave study of the beach area South of Goat Island, Tutuila, Samoa in the interest of developing design information for a usable beach and swimming area behind the reef.
British Guiana	A team of four engineers from New England Division and Coastal Engineering Research Center made an inspection and completed a report on an evaluation of methods of construction and repairs of shore protection works.
Ecuador	A report was completed concerning the need for acquisition of a dredge for navigation improvement at the Port of Guayaquil.
Egypt	A representative of the Office, Chief of Engineers was named by UNESCO as a member of a group of experts for reviewing plans for the salvage of the Philae Monuments above Aswan High Dam in Nubia. The group made a field inspection and reviewed preliminary plans prepared by NEDECO, The Hague, Netherlands. A plan was recommended for hydraulic fill dikes around the island on which the monuments are located. Preliminary investigations for the final design were recommended, and a time schedule for the work was suggested. The report of the group was submitted to UNESCO, Paris.

Country	*Description*
India	Broad scope assistance on the Brahmaputra River flood problems at many locations was requested by the Agency for International Development. An engineer from the Mississippi River Commission performed a site inspection, reviewed available information on the flood problems and prepared a report with recommendations. Request was made by the Agency for International Development for assistance on the design of a cooling water intake for a steam powerplant on the Brahmaputra River. An engineer from the Mississippi River Commission visited the site. Following this visit, and a meeting of a board, a report including recommended plan of development, was prepared and submitted.
Okinawa	A team of engineers from the New England Division and the Honolulu District made a survey and study of the water supply including required dams and pipelines. A conference between the Office, Chief of Engineers and the New England Division was held to discuss and establish the design requirements for detailed planning. The New England Division continued with the design work.
Southeast Asia	Training was initiated and continued regarding analysis and feasibility of applying Columbia River systems analysis and electronic computer techniques to flood control problems in the Lower Mekong River Basin. Training participants during the period were from Thailand, Laos and the Philippines.

6. ATLANTIC-PACIFIC INTEROCEANIC CANAL STUDY

The Atlantic-Pacific Interoceanic Canal Study Commission, appointed on April 18, 1965, in compliance with Public Law 88–609, is studying the feasibility of a sea level canal in the American Isthmus, whether it should be built by nuclear or conventional means, the best location, and the estimated cost. The law limits the study time to June 30, 1968, and the cost to $17,500,000. The Commission appointed the Chief of Engineers as the Agent for Engineering Feasibility, with the responsibility of coordinating the efforts of the Corps of Engineers, the Atomic Energy Commission, the Panama Canal Co. and other government agencies working on this phase of the study.

Four canal alinements are being considered including—(*a*) converting the existing Panama lock canal to sea level operation using conventional excavation methods; (*b*) a route in the Darien

region of Panama using nuclear methods; (*c*) a route in northwest Colombia using nuclear and conventional methods; and (*d*) a route in Nicaragua using conventional methods.

Agreements for field operations with Panama and Colombia were consummated February 15, and October 25, 1966. Because rain restricts field work except during the dry season (usually January through April), only limited work was possible during 1966 on the Darien route, however, data gathering operations will be in full-swing during the 1967 dry season. In northwest Colombia, operations will start at the beginning of the 1967 dry season. Data gathering will be slower than in the Darien because of the initial need to build camps, roads, airstrips, and weather and hydrologic stations.

The field work is under the direction of the Field Director, Interoceanic Canal Study Commission, who maintains a staff in the Canal Zone. The Atomic Energy Commission, with the responsibility for collecting data for studies on radiological safety, seismic effects, and acoustic wave effects, is represented in the Field Director's staff. The Panama Canal Co. supports the Field Director in his operations.

Jacksonville District, in addition to coordinating the operations of the Corps of Engineers and the Atomic Energy Commission, is working on the problem of converting the Panama lock canal to sea level operation. The study emphasis has been placed on selecting the route and devising a construction procedure which will minimize costs. About a billion and a quarter cubic yards of excavation will be required. Jacksonville District is also considering the modernization of the present lock canal as an alternative to a sea level canal.

The Atomic Energy Commission is evaluating the field data on radiological safety, seismic effects and acoustic wave effects. The Nuclear Cratering Group of the Corps of Engineers is designing the nuclear channels.

Commission fiscal year 1967 funds amount to about $6.7 million, of which approximately $4.4 million will be expended by the Corps of Engineers.

7. LAKE SURVEY

The U.S. Lake Survey has actively continued its program of producing and updating navigation charts of the Great Lakes and

the outflow rivers, the New York State Barge Canals, Lake Champlain, and the Minnesota-Ontario border lakes. These include the bound volumes of large-scale charts issued primarily to serve the increasing needs of recreational boating interests. Information was gathered and studies and investigations were conducted on matters pertaining to the applied hydraulics and hydrology of the Great Lakes. The program of research on Great Lakes Water Resources was continued.

Revisory surveys of harbors on Lake Michigan were completed and surveys were made at selected harbors on Lakes Huron and Superior and along a portion of the St. Marys River. Hydraulic and hydrology work included the taking of discharge measurements and collection of water level data. Consulting engineer services were provided to various international boards and committees.

The program for research and investigation included all aspects of "freshwater" oceanography, coastal engineering, and related scientific fields pertinent to development of improved utilization of water resources of the Great Lakes system. The program included the following fields of research: water motion, shore processes, water characteristics, water quantities, and ice and snow. Work continued on various research projects such as the study of harbor currents in selected harbors in Lakes Erie, Michigan, and Superior; deepwater waves and hindcasting for three of the Great Lakes; and short-period water level disturbances in Lake Michigan. Other projects included the study of energy transfer at air-water interfaces; sediment barrier effects in the St. Clair River; physical and chemical water characteristics in Lakes Erie and Huron. Observation of ice cover in the lakes was continued. A study of the effectiveness of the compensating works in the Detroit River was initiated.

For detailed report of operations under this activities see volume 2, U.S. Lake Survey.

8. WASHINGTON, D.C., WATER SUPPLY

With funds appropriated for the District of Columbia, the Corps of Engineers continued the operation, maintenance, repair, and protection of the water supply facilities, known as the Washington Aqueduct, to provide an uninterrupted and adequate supply of purified water to the distribution systems of the District of Columbia

and adjacent Maryland and Virginia areas as authorized by law. The maximum daily consumption provided by the existing facilities was 260 million gallons and the average daily consumption was 178 million gallons.

In order to meet the future demands for water, construction work continued on the long-range program.

For detailed report on maintenance, operation and capital outlay of the Washington, D.C., water supply facilities, see volume 2, "Baltimore District."

9. WATER FOR PEACE PROGRAM

Water for Peace Program. President Johnson announced a Water for Peace Program on October 7, 1965, in an address to the delegates to the First International Symposium on Desalination in Washington, D.C., at which time he also stated that an international conference on the world's water problems would be held. As a result of an exchange of correspondence between the Secretary of State and the Secretary of the Interior in November 1965, an Interdepartmental Committee on Water for Peace was established with the General Counsel of the Army representing the Department of the Army. The Committee held its organizational meeting in December 1965. The Interdepartmental Committee established an Interdepartmental Task Force on Water for Peace with Army membership from the Office, Chief of Engineers. Nine task units were established by the Task Force and Office, Chief of Engineers personnel served on six of the groups. Each task unit prepared reports on assigned subjects, potentially a part of the Water for Peace Program report to be submitted to the President. First draft of reports were completed in February 1966 with final draft still under review at end of fiscal year 1966.

Secondary activities of the Corps of Engineers in the Water for Peace Program during fiscal year 1966 included the preparation of a report on international water activities of the Department of the Army, supplying photographs of international water projects and furnishing a list of foreign nationals who might be considered for participation in the International Conference. A separate Program Commitee for the International Conference to be held in Washington, D.C. in May 1967 was established with a representative of the Office, Chief of Engineers serving for the Department of the Army.

10. PUBLICATIONS

The following publications pertaining to civil works activities have been issued.

A. Available at the Government Printing Office, Washington, D.C., 20402, at indicated price:

1. Port Series:
   - No. 4 — Ports of Southern New England (Providence, R.I.; Fall River, Mass.; and New London, New Haven, and Bridgeport, Conn.) $2.00
   - No. 37 — The Ports of Port Angeles, Anacortes, Everette, and Bellingham, Wash. 2.00
   - No. 38 — The Port of Ketchikan, Alaska .... .50
2. Transportation Series:
   - No. 3 — Transportation Lines on the Great Lakes System, 1965 .... .60
   - No. 4 — Transportation Lines on the Mississippi River System and the Gulf Intracoastal Waterway, 1965 .... 2.50
   - No. 5 — Transportation Lines on the Atlantic, Gulf, and Pacific Coasts, 1965 .... 3.00

B. Available at U.S. Army Engineer District, Lake Survey, Detroit, Mich., 48226, at listed price:

1. Great Lakes Pilot, 1965 (including supplements) . . . $3.25
2. Waterborne Commerce of the United States, calendar year 1964:
   - Part 1 — Waterways and Harbors: Atlantic Coast 1.35
   - Part 2 — Waterways and Harbors: Gulf Coast, Mississippi River System and Antilles. 1.50
   - Part 3 — Waterways and Harbors: Great Lakes.. 1.25
   - Part 4 — Waterways and Harbors: Pacific Coast, Alaska, and Hawaii 1.20
   - Part 5 — National summaries .... .30

C. The following complete revisions of existing manuals were published during the fiscal year. These manuals are available at U.S. Army Engineer Waterways Experiment Station at indicated price:

- EM 1110–2–2000, Standard Practice for Concrete.. $ .50
- EM 1110–2–3300, Beach Erosion Studies.......... .35

A–1. *Total U.S. Waterborne Commerce for Calendar Year 1956–65*

(In millions of tons of 2,000 pounds)

Year	Total	Foreign						Domestic						Intra-territory
		Imports			Exports			Total	Coastwise	Lakewise	Internal	Intraport	Local	
		Total	Coastal ports	Great Lakes ports	Total	Coastal ports	Great Lakes ports							
1956	1,092.9	174.2	163.3	10.9	152.5	126.5	26.0	766.2	205.9	174.0	269.7	53.1	61.3	2.2
1957	1,131.4	186.4	176.2	10.1	172.2	146.9	25.3	772.9	196.4	182.2	281.1	50.2	60.6	2.4
1958	1,004.5	189.5	181.5	8.0	119.4	101.6	17.8	695.7	194.1	132.3	261.1	48.9	56.5	2.8
1959	1,052.4	213.5	198.6	14.9	112.2	91.6	20.6	726.7	205.5	131.2	282.3	49.7	57.1	[1]1.0
1960	1,099.9	211.3	198.5	129.9	128.0	104.8	23.2	760.6	209.2	155.1	291.1	49.5	54.7	1.0
1961	1,062.2	200.2	188.2	12.0	129.2	106.0	23.2	732.8	206.9	136.8	294.1	43.2	50.7	1.1
1962	1,129.4	222.7	207.0	15.7	135.9	110.5	25.4	770.8	215.5	135.7	316.1	47.9	54.4	1.3
1963	1,173.8	227.4	209.4	18.0	158.3	129.8	28.5	788.1	213.9	141.7	331.9	45.6	53.4	1.6
1964	1,238.1	248.6	224.4	24.2	173.3	142.9	30.5	816.2	205.7	151.4	357.9	43.0	56.6	1.6
1965	1,272.9	269.8	244.9	25.0	173.9	142.1	31.8	829.2	201.5	153.7	369.6	([2])	102.9	1.5

[1] Traffic within the States of Alaska and Hawaii transferred to other domestic traffic categories.
[2] Included in local.
Note. Totals represent the sums of unrounded figures, hence they may vary slightly from the sums of the rounded amounts.

A-2. Project Harbors, Commerce Reported for Calendar Year 1965
(In tons of 2,000 pounds)

Harbor	Tons
ALABAMA	
Dauphin Island Bay	751
Fly Creek (Fairhope)	197
Guntersville	1,129,476
Mobile Harbor	21,836,686
ALASKA	
Anchorage	1,080,094
Cordova Harbor	43,169
Craig Harbor	2,943
Dillingham Harbor	13,975
Elfin Cove	822
Homer	10,871
Iliuliuk Harbor (Dutch Harbor)	213,601
Juneau Harbor	100,307
Ketchikan Harbor	1,319,238
Kodiak Harbor	127,584
Metlakatla Harbor	8,009
Nome Harbor	28,197
Pelican Harbor	6,697
Petersburg Harbor	126,442
Port Alexander Harbor[1]	-------
Seldovia Harbor	20,566
Seward Harbor	37,462
Sitka Harbor	772,060
Skagway Harbor	200,945
Valdez Harbor	51,336
Whittier Harbor	177,249
Wrangell Harbor	396,668
ARKANSAS	
Helena	1,786,942
CALIFORNIA	
Berkeley	100,595
Bodega Bay	1,688
Crescent City Harbor	434,780
Halfmoon Bay	172
Humboldt Harbor and Bay	723,447
CALIFORNIA-Con.	
Long Beach Harbor	12,826,908
Los Angeles Harbor	21,000,473
Monterey Harbor	49,586
Morro Bay Harbor	4,131
Moss Landing Harbor	142,854
Newport Bay Harbor	639
Oakland Harbor	5,030,512
Redondo Beach (King Harbor))	56
Redwood City Harbor	3,484,105
Richmond Harbor	15,449,556
Sacramento	2,258,281
San Diego	1,657,918
San Francisco Harbor	4,989,705
Santa Barbara Harbor	2,008
Stockton	2,835,701
CONNECTICUT	
Branford Harbor	75
Bridgeport Harbor	2,458,938
Clinton Harbor	358
Duck Island Harbor[1]	-------
Fivemile River Harbor	1,118
Greenwich Harbor	129,263
Guilford Harbor	3,040
Milford Harbor	1
New Haven Harbor	9,770,680
New London Harbor	974,188
Norwalk Harbor	1,233,740
Southport Harbor[1]	-------
Stamford Harbor	844,098
Stonington Harbor	1,011
Westport Harbor and Saugatuck River	13,295
DELAWARE	
Wilmington Harbor	2,391,716
DISTRICT OF COLUMBIA	
Washington Harbor	1,991,993

See footnote at end of table.

A–2. Project Harbors, Commerce Reported for Calendar Year 1965—Continued

Harbor	*Tons*
FLORIDA	
Apalachicola Bay	34,340
Canaveral Harbor	924,033
Carrabelle Harbor	40,451
Cedar Keys Harbor	1,896
Charlotte Harbor	1,834,997
Eau Gallie Harbor	145
Everglades Harbor, Collier County	1,535
Fernandina Harbor	209,656
Fort Myers Beach	18,973
Fort Pierce Harbor	104,527
Horseshoe Cove	434
Jacksonville Harbor	9,755,088
Key West Harbor	260,197
Melbourne Harbor	85
Miami Harbor	1,399,514
Palm Beach Harbor	1,079,865
Panacea Harbor	1,980
Panama City Harbor	1,443,218
Pensacola Harbor	651,265
Port Everglades Harbor	6,937,119
Port St. Joe Harbor	254,805
St. Augustine Harbor	12,536
St. Petersburg Harbor	347,449
Tampa Harbor	19,829,071
GEORGIA	
Brunswick Harbor	857,589
Darien Harbor	853
Savannah Harbor	4,452,282
HAWAII	
Hilo Harbor, Hawaii	774,955
Honolulu Harbor, Oahu	5,479,958
Kahului Harbor, Maui	741,189
Kaunakakai Harbor, Molokai	322,466
Kawaihae Harbor, Hawaii	240,405
Nawiliwili Harbor, Kauai	446,601
Port Allen Harbor, Kauai	92,381
ILLINOIS	
Calumet Harbor and River	28,065,007
Chicago Harbor	902,111
Port of Chicago	45,973,244
Waukegan Harbor	457,090
INDIANA	
Calumet Harbor and River	28,065,007
Indiana Harbor	18,567,036
Michigan City Harbor	99,973
Mount Vernon	3,696,509
KENTUCKY	
Louisville	8,087,828
Louisiana	
Baton Rouge	31,658,797
Lake Charles (Calcasieu River and Pass)	14,469,783
New Orleans	88,876,872
MAINE	
Bar Harbor	108
Bass Harbor	643
Beals Harbor	652
Belfast Harbor	2,654
Boothbay Harbor	4,144
Camden Harbor	91
Cape Porpoise Harbor	22,795
Corea Harbor	682
Eastport Harbor	13,355
Hendricks Harbor	123
Isle au Haut Thoroughfare	606
New Harbor	933
Northeast Harbor[1]	-----
Portland Harbor	18,462,915
Rockland Harbor	78,858
Rockport Harbor	144

See footnote at end of table.

A-2. Project Harbors, Commerce Reported for Calendar Year 1965—Continued

Harbor	Tons
MAINE-Con.	
Searsport Harbor	1,417,521
South Bristol Harbor	382
Southwest Harbor	2,897
Stonington Harbor	7,952
Thomaston Harbor	1
Wood Island Harbor and the Pool at Biddeford	187
York Harbor	422
MARYLAND	
Annapolis Harbor	19,657
Baltimore Harbor and Channels	44,267,160
Black Walnut Harbor	381
Breton Bay	18,120
Cambridge Harbor	149,580
Claiborne Harbor	1,057
Crisfield Harbor	35,297
Lowes Wharf, Talbot County	3,824
Nanticoke River at Bivalve	1,042
Nanticoke River at Nanticoke	6,071
Ocean City Harbor and Inlet and Sinepuxent Bay	10,565
Queenstown Harbor	18
Rock Hall Harbor	3,761
Tilghman Island Harbor	2,760
MASSACHUSETTS	
Beverly Harbor	211,128
Boston, Main Waterfront	16,884,741
Chatham (Stage) Harbor	846
Cohasset Harbor	282
Cotuit Harbor[1]	-----
Cuttyhunk Harbor	724
Duxbury Harbor	1,033
Edgartown Harbor	2,331
Fall River Harbor	3,661,963
Falmouth Harbor	2,278
MASSACHUSETTS-Con.	
Gloucester Harbor	187,799
Harbor of Refuge, Nantucket	44,813
Hingham Harbor[1]	-----
Hyannis Harbor	359
Lynn Harbor	1,056
Manchester Harbor	243
Marblehead Harbor	553
New Bedford and Fairhaven Harbor	414,786
Newburyport Harbor	88
Plymouth Harbor (including North Plymouth)	7,791
Pollock Rip Shoals, Nantucket Sound[1]	-----
Port of Boston	19,854,685
Provincetown Harbor	10,271
Rockport Harbor	295
Salem Harbor	1,417,305
Scituate Harbor	1,614
Vineyard Haven Harbor	63,912
Wareham Harbor[1]	-----
Wellfleet Harbor	491
MICHIGAN	
Algonac	27,732
Alpena Harbor	3,146,177
Au Sable Harbor and River (Oscoda)	154
Big Bay Harbor	20
Black River Harbor	41
Caseville Harbor	50
Cedar River Harbor[1]	-----
Charlevoix Harbor	38,290
Cheboygan Harbor	118,342
Chippewa Harbor (Isle Royale)[1]	-----
Detour and vicinity	318,746
Drummond Island	2,622,291
Eagle Harbor	3
Frankfort Harbor	1,725,505

See footnote at end of table.

A–2. Project Harbors, Commerce Reported for Calendar Year 1965—Continued

Harbor	Tons
MICHIGAN-Con.	
Gladstone Harbor	337,920
Grand Haven Harbor and Grand River	3,243,868
Grand Marais Harbor (Harbor of Refuge)	18
Grand Traverse Bay Harbor [1]	-----
Harbor Beach, Harbor of Refuge	39,680
Harrisville Harbor	174,741
Holland Harbor	258,729
Lac La Belle Harbor [1]	-----
Leland Harbor	813
Lime Island	174,551
Ludington Harbor	3,978,708
Mackinac Harbor	22,015
Manistee Harbor	582,928
Manistique Harbor	227,963
Marine City	122,837
Marquette Harbor	1,664,340
Marysville	508,546
Menominee Harbor and River	516,670
Monroe Harbor	58,099
Muskegon Harbor	3,344,557
Ontonogan Harbor	25,151
Pentwater Harbor	6
Pine River[1]	-----
Port Huron	940,004
Port of Detroit	32,262,008
Port Sanilac Harbor	16
Presque Isle Harbor	5,944,623
Rogers City Harbor	89
St. Clair	3,698,891
St. James Harbor (Beaver Island)	1,416
St. Joseph Harbor	600,641
Saugatuck Harbor and Kalamazoo River	1,261
Sault Ste. Marie	320,480
Sebewaing	26
South Haven Harbor	110,950
Traverse City Harbor	229,349
White Lake Harbor	33,847
Whitefish Point Harbor	160
MINNESOTA	
Beaver Bay Harbor	12
Duluth-Superior Harbor	46,177,391
Grand Marais Harbor	26,998
Knife River Harbor	24
Lutsen Harbor[1]	-----
Minneapolis	1,005,875
St. Paul	4,233,897
Two Harbors (Agate Bay)[1]	-----
Warroad Harbor	972
MISSISSIPPI	
Biloxi Harbor	138,351
Greenville	1,295,485
Gulfport Harbor	460,751
Natchez	599,137
Pascagoula Harbor	9,254,060
Pass Christian Harbor	1,744
Vicksburg	1,567,381
MISSOURI	
Port of Kansas City	1,825,963
St. Louis	9,797,503
NEW HAMPSHIRE	
Portsmouth Harbor	1,654,508
Rye Harbor	112
NEW JERSEY	
Keyport Harbor	7
NEW YORK	
Barcelona	15
Cape Vincent Harbor	5
Dunkirk Harbor	18,927

See footnote at end of table.

A-2. Project Harbors, Commerce Reported for Calendar Year 1965—Continued

Harbor	*Tons*
NEW YORK-Con.	
Echo Bay Harbor	145,883
Great Kills Harbor, Staten Island	1,182
Great Sodus Bay Harbor	1,137,673
Greenport Harbor	24,274
Hay (West) Harbor	4,375
Hempstead Harbor	3,527,604
Huntington Harbor	522,212
Lake Montauk Harbor	3,392
Mamaroneck Harbor	66,865
Mattituck Harbor	38,594
Milton Harbor	15,775
Morristown Harbor[1]	-----
New Rochelle Harbor[1]	-----
Niagara Falls	7,424
Northport Harbor	126,129
Ogdensburg Harbor	358,200
Olcott Harbor[1]	-----
Oswego Harbor	252,566
Peekskill Harbor	141,018
Plattsburg Harbor [1]	-----
Port Chester Harbor	360,550
Port Henery Harbor	11,021
Port Jefferson Harbor	1,977,106
Port of Albany	7,872,937
Port of Buffalo	17,849,513
Port of New York	153,854,782
Rochester (Charlotte) Harbor	761,430
Rondout Harbor	497,143
Sackets Harbor	66,445
Sag Harbor	33,395
Saugerties Harbor[1]	-----
Tarrytown Harbor	382,496
Tonawanda Harbor	649,397
Waddington Harbor	49,613
Wilson Harbor	1
NORTH CAROLINA	
Beaufort Harbor	85,685
Belhaven	22,033
Edenton Harbor	43,266

Harbor	*Tons*
NORTH CAROLINA-Con.	
Manteo (Shallowbag) Bay	59,257
Morehead City Harbor	693,343
Port of Wilmington (see also Wilmington Harbor, N.C., for waterway data)	3,985,719
Silver Lake Harbor	5,334
OHIO	
Ashtabula Harbor	11,134,326
Cincinnati	9,010,727
Cleveland Harbor	21,960,213
Conneaut Harbor	8,806,917
Fairport Harbor	1,956,489
Huron Harbor	1,182,590
Lorain Harbor	6,539,731
Port Clinton Harbor	31,447
Put-In-Bay Harbor	7,305
Sandusky Harbor	2,207,789
Toledo Harbor	45,016,077
Vermilion Harbor	498
OREGON	
Coos Bay, Inside Channel bar to Millington	4,115,031
Depoe Bay	235
Oregon Slough (North Portland Harbor)	568,054
Port of Astoria	1,130,213
Port of Portland	16,726,210
Port of St. Helens	408,476
Tillamook Bay and Bar	257,200
Yaquina Bay and Harbor	232,805
PENNSYLVANIA	
Aliquippa-Rochester	6,876,441
Erie Harbor	1,187,417
Philadelphia Harbor	47,734,820
Pittsburgh	8,274,919

See footnote at end of table.

A-2. Project Harbors, Commerce Reported for Calendar Year 1965—Continued

Harbor	*Tons*
PENNSYLVANIA-Con.	
Port of Clairton-Elizabeth	13,686,726
RHODE ISLAND	
Great Salt Pond, Block Island	2,257
Harbor of Refuge, Block Island	2,909
Harbor of Refuge, Point Judith and Point Judith Pond	23,874
Newport Harbor	94,238
Providence River and Harbor	9,102,548
Wickford Harbor	7,871
SOUTH CAROLINA	
Charleston Harbor	4,950,395
Georgetown Harbor (Winyah Bay)	1,082,511
Port Royal Harbor	4,711
TENNESSEE	
Chattanooga	1,252,287
Knoxville	552,805
Memphis	7,443,489
Port of Nashville	2,528,305
TEXAS	
Aransas Pass	79,970
Beaumont	31,565,743
Brazos Island Harbor	4,876,713
Corpus Christi	20,282,869
Freeport Harbor	4,590,577
Galveston (Galveston Channel)	3,716,962
Harbor Island	9,711,483
Houston (Houston Ship Channel)	59,831,766
Orange	1,144,176
TEXAS-Con.	
Palacios	321,539
Port Arthur	25,413,796
Port Bolivar	300
Port Lavaca-Point Comfort	4,597,167
Port Mansfield	183,510
Rockport	1,743
Sabine Pass Harbor	234,455
Texas City (Texas City Channel)	18,155,441
Victoria	961,106
VERMONT	
Burlington Harbor	546,268
VIRGINIA	
Cape Charles City Harbor	73,264
Horn Harbor	4,460
Monroe Bay and Creek	3,765
Norfolk Harbor	40,017,109
Port of Hopewell	694,412
Port of Newport News	14,234,833
Port of Richmond	1,730,305
Portsmouth Harbor, Channel to Nansemond Ordnance Depot[1]	-----
Potomac River at Alexandria	260,014
Winter Harbor	968
WASHINGTON	
Anacortes Harbor	7,728,456
Bellingham Bay and Harbor	1,881,085
Blaine Harbor	31,691
Everett Harbor	3,432,933
Grays Harbor an Chehalis River	2,387,908
Hammersley Inlet (Shelton Harbor)	888,563

See footnote at end of table.

A-2. Project Harbors, Commerce Reported for Calendar Year 1965—Continued

Harbor	Tons
WASHINGTON-Con.	
Longview	4,161,251
Neah Bay	227,230
Olympia Harbor	769,436
Port Angeles Harbor	2,340,707
Port Gamble Harbor	261,357
Port of Kalama	1,083,366
Port Townsend Harbor	852,636
Seattle Harbor	14,747,754
Tacoma Harbor	6,138,431
Vancouver	1,627,135
Willapa River and Harbor, and Naselle River	670,132
WEST VIRGINIA	
Huntington	15,991,955
WISCONSIN	
Algoma Harbor[1]	-----
Ashland Harbor	873,310
Bayfield Harbor[1]	-----
Big Suamico River[1]	-----
Cornucopia Harbor	94
Detroit Harbor	10,984
Duluth-Superior Harbor	46,177,391
Green Bay Harbor	2,529,915
Jackson Harbor[1]	-----
Kenosha Harbor	37,811
Kewaunee Harbor	1,181,615
Manitowoc Harbor	2,323,538
Menominee Harbor and River	516,670
WISCONSIN-Con.	
Milwaukee Harbor	6,387,733
Oconto Harbor[1]	-----
Pensaukee Harbor[1]	-----
Port Washington Harbor	683,560
Port Wing Harbor	175
Racine Harbor	141,603
Saxon Harbor[1]	-----
Sheboygan Harbor	457,955
Two Rivers Harbor	102,875
PUERTO RICO	
Arecibo Harbor	5,134
Fajardo Harbor	44,376
Guayanes Harbor[1]	-----
Mayaguez Harbor	288,278
Ponce Harbor	644,826
San Juan Harbor	7,060,037
VIRGIN ISLANDS	
Christiansted Harbor, St. Croix	97,660
St. Thomas Harbor	193,435
MIDWAY ISLAND	
Welles Harbor	36,016
WAKE ISLAND	
Wake Island Harbor, Pacific Ocean	237,830

[1] No commerce reported.

A-3. Commerce at Selected Areas, Calendar Year 1965

(In tons of 2,000 pounds)

Area	*Tons*
Delaware River and tributaries, Trenton, N.J., to the sea:	
Burlington-Florence-Roebling, N.J.	768,912
Camden-Gloucester, N.J.	5,299,713
Chester, Pa.	802,413
Marcus Hook, Pa., and vicinity	17,456,904
New Castle, Del., and vicinity	11,637,364
Paulsboro, N.J., and vicinity	18,460,229
Penn Manor, Pa., and vicinity	11,397,719
Philadelphia Harbor, Pa.	47,734,820
Riverton-Delanco-Beverly, N.J.	724,325
Trenton Harbor, N.J.	2,719,047
Wlmington Harbor, Del.	2,391,716
Other	1,345,862
Gross total	120,739,024
Net total	106,905,680
Hampton Roads, Va.:	
Channel from Phoebus, Va., to deepwater in Hampton Roads	2,639
Hampton Creek, Va.	373,465
Norfolk Harbor, Va.	40,017,109
Port of Newport News, Va.	14,234,833
Gross total	54,626,046
Net total	54,105,576
Corpus Christi Bay, Tex.:	
Corpus Christi, Tex.	20,282,869
Harbor Island, Tex.	9,711,483
Gross total	29,994,352
Net total	29,928,134
San Francisco Bay, Calif.:	
Carquinez Strait, Calif.	10,718,643
Oakland Harbor, Calif.	5,030,512
Redwood City Harbor, Calif.	3,484,105
Richmond Harbor, Calif.	15,449,556
Sacramento River, Calif.	2,459,819
San Francisco Harbor, Calif.	4,989,705
San Joaquin River and tributaries, Calif.	5,028,516
San Pablo Bay and Mare Island Strait, Calif.	2,914,906
Suisun Bay Channel, Calif.	2,964,621

A-3. Commerce at Selected Areas, Calendar Year 1965—Continued

(In tons of 2,000 pounds)

Area	*Tons*
San Francisco Bay, Calif.:—(Continued)	
Other	3,862,051
Gross total	56,902,434
Net total	45,138,933
Chicago, Ill., and Ind.:	
Buffington Harbor, Ind	1,693,771
Gary Harbor, Ind	7,088,903
Indiana Harbor, Ind	18,567,036
Port of Chicago, Ill	45,973,244
Gross total	73,322,954
Net total	71,874,631

A-4. Ton-Mileage of Freight Carried on U.S. Inland Waterways, by System, Calendar Year 1965

System	*Ton-miles*
Atlantic coast waterways	27,781,436,000
Gulf coast waterways	21,807,792,000
Pacific coast waterways	6,629,670,000
Mississippi River system, including Ohio River and tributaries	96,593,337,000
Great Lakes system[1]	109,608,579,000
Total	262,420,814,000

[1] Does not include traffic between foreign ports.

A-5. Project Waterways, Commerce Reported for Calendar Year 1965
(In tons of 2,000 pounds)

Waterway	*Tons*	*Total ton-miles (000 omitted)*
ATLANTIC COAST		
Abbapoola Creek, S.C.[2]		
Aberdeen Creek, Va	2,329	2
Absecon Creek, N.J	6	(1)
Absecon Inlet, N.J	73,779	148
Alloway Creek, N. J.[2]		
Altamaha River, Ga	31,303	188
Anacostia River, D.C	1,453,933	2,908
Annisquam River, Mass	558	1
Appomattox River, Va.[2]		
Aquia Creek, Va	2	(1)
Ashley River, S.C	13,478	81
Atlantic Intracoastal waterway between Norfolk, Va., and the St. Johns River, Fla. (net)	3,322,813	714,062
U.S. Army Engineer District, Norfolk:		
Via Dismal Swamp Canal Route	175,509	4,739
Via Great Bridge Lock Route	1,249,645	41,700
U.S. Army Engineer District, Wilmington	2,064,237	369,209
U.S. Army Engineer District, Charleston	1,400,181	182,024
U.S. Army Engineer District, Savannah	1,085,110	103,183
U.S. Army Engineer District, Jacksonville	702,484	13,217
Back Creek (Anne Arundel County), Md	401	(1)
Bakers Haulover Inlet, Fla.[2]		
Barnegat Inlet, N.J	11,650	12
Bay Ridge and Red Hook Channels, N.Y	10,113,477	38,354
Bay River, N.C	6,498	56
Beach Creek, Va	899	1
Beresford Creek, S.C.[2]		
Big Timber Creek, N.J	269,286	81
Black River, N.C.[2]		
Blackwater River, Va	81,197	1,096
Bransons Cove, Va	4,699	1
Breton Bay, Md	18,120	113
Broad Creek, Va	504	(1)
Broad Creek River, Del	6,501	53
Broad Creek, Somerset County, Md	1,646	5
Broadkill River, Del.[2]		
Broadwater Creek, Md	6	(1)
Bronx River, N.Y	526,835	896
Browns Creek, N.Y	300	(1)
Buttermilk Channel, N.Y	2,836,330	5,860
Cadle Creek, Md[2]		
Cape Cod Canal, Mass	10,661,472	186,576
Cape Fear River above Wilmington, N.C	266,773	20,088

See footnotes at end of table.

A.5.—Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	Tons	Total ton-miles (000 omitted)
ATLANTIC COAST—Continued		
Cape May Canal, N.J	40,524	163
Carters Creek, Va	22,889	30
Cashie River, N.C	28,700	588
Channel between Staten Island and Hoffman and Swinburne Islands, N.Y	772	1
Channel connecting Throughfare Bay with Cedar Bay, N.C	650	3
Channel connecting York River, Va., with Back Creek to Slaight's Wharf	2,402	2
Channel from Back Sound to Lookout Bight, N.C	328	1
Channel from Pamlico Sound to Avon, N.C	6,481	16
Channel from Pamlico Sound to Rodanthe, N.C	582	1
Channel from Phoebus, Va., to deep water in Hampton Roads	2,639	2
Channel to Island Creek, St. George Island, Md	199	(1)
Channel to Newport News, Va	17,669,679	57,426
Cheesequake Creek, N.J.[2]		
Chelsea River, Mass	7,326,847	10,990
Chester River, Md	60,166	1,634
Chester River, Pa.[2]		
Chincoteague Bay, Md., and Va	8,193	2
Choptank River, Md	270,039	3,152
Chowan River, N.C	122,291	4,899
Coan River, Va	8,597	17
Cobscook Bay, Maine	15,913	37
Cockrell Creek, Va	105,343	158
Cohansey River, N.J	72,169	1,371
Cold Spring Inlet, N.J	21,122	21
Coney Island Channel, N.Y	6,242,128	8,115
Coney Island Creek, N.Y	266,634	293
Congaree River, S.C.[2]		
Connecticut River above Hartford, Conn.[2]		
Connecticut River below Hartford, Conn	3,075,947	141,493
Contentnea Creek, N.C.[2]		
Cooper River, N.J	19,927	20
Corsica River, Md.[2]		
Courtenay Channel, Fla[2]		
Cranes Creek, Va	322	(1)
Damariscotta River, Maine	536	3
Davis Creek, Va	4,148	3
Deep Creek, Accomack County, Va	453	1
Deep Creek, Newport News, Va	11,578	23
Delaware River:		
Trenton, N.J., to the sea (net)	107,315,410	9,600,930

See footnotes at end of table.

A.5.—Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
ATLANTIC COAST—Continued		
At Camden, N.J	2,467,365	(4)
Between Philadelphia, Pa., and Trenton, N.J	20,442,541	286,196
Harbor of Refuge, Delaware Bay, Del	26,159	39
Philadelphia, Pa., to the sea	105,410,493	9,314,735
Dennis Creek, N.J.[2]		
Dorchester Bay, Mass	70,064	210
Double Creek, N.J.[2]		
Drum Inlet, N.C	46	(1)
Duck Point Cove, Md	1,402	1
Dymers Creek, Va	9,063	9
East Chester Creek, N.Y	2,016,290	9,073
East River, N.Y	50,330,250	402,642
East Rockaway Inlet, N.Y	1,809,701	1,810
Elizabeth River, N.J.[2]		
Elk and Little Elk Rivers, Md	824	3
Essex River, Mass	32	(1)
Fancy Bluff Creek, Ga.[2]		
Far Creek, N.C	33,568	90
Fire Island Inlet, N.Y	294,243	353
Fishing Bay Tributaries, Dorchester County, Md	4,483	25
Fishing Creek, Calvert County, Md	66	(1)
Flushing Bay and Creek, N.Y	2,107,020	6,742
Fort Point Channel, Mass	1,750	1
Glen Cove Creek, N.Y	189,860	142
Goshen Creek, N.J.[2]		
Governors Run, Md	110	(1)
Gowanus Creek Channel, N.Y	4,588,299	2,897
Great Pee Dee River, S.C	4,256	43
Great South Bay, N.Y	321,219	5,561
Hackensack River, N.J	4,577,762	41,200
Hampton Creek, Va	373,465	1,046
Harlem River, N.Y	1,061,846	2,624
Hellens Creek, Md.[2]		
Herring Bay and Rockhold Creek, Md	317	(1)
Herring Creek, Md	977	4
Honga River and Tar Bay, Md	5,686	23
Hoskins Creek, Va	9,386	8
Housatonic River, Conn	953,837	4,769
Hudson River, N.Y., and N.J.:		
Deep Water in Upper Bay, N.Y., to Waterford, N.Y. (net)	35,887,118	1,934,286
Mouth of Spuyten Duyvil Creek (Harlem River) to Waterford, N.Y	21,616,404	1,552,184
Hudson River Channel, N.Y., and N.J	34,052,791	389,147

See footnotes at end of table.

A.5.—Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
ATLANTIC COAST—Continued		
Hull Creek, Va	279	(1)
Indian River Inlet and Bay, Del	7	(1)
Inland Waterway between Rehoboth Bay and Delaware Bay, Del	800	9
Inland Waterway from Delaware River to Chesapeake Bay, Del., and Md.—Chesapeake and Delaware Canal	10,715,319	492,905
Intracoastal Waterway:		
Jacksonville to Miami, Fla	867,496	48,170
Miami to Key West, Fla	79,091	2,302
Ipswich River, Mass	324	1
Jackson Creek, Va	23	(1)
Jamaica Bay, N.Y	6,131,073	73,573
James River, Va	5,103,453	321,517
Jones Inlet, N.Y	3,988	8
Josias River, Maine	97	(1)
Kennebec River, Maine	25,969	1,087
Kennebunk River, Maine	221	(1)
Kings Creek, Northampton County, Va	800	1
Knapps Narrows, Md	4,957	8
Knobbs Creek, N.C[2]		
La Trappe River, Md	6,230	22
Lake Crescent and Dunns Creek, Fla	225	1
Lake Ogleton, Md[2]		
Leipsic River, Del	3	(1)
Lemon Creek, Staten Island, N.Y.[2]		
Little Creek, Queen Annes County, Md	1,616	(1)
Little Machipongo River, Va	40,811	57
Little Neck Bay, N.Y[2]		
Little River, Del	12	(1)
Little River (Creek), Va	182,456	182
Little Wicomico River, Va	5,090	11
Locklies Creek, Va	129	(1)
Lockwoods Folly River, N.C	51	(1)
Long Island Intracoastal Waterway, N.Y	2,745	9
Lower Entrance Channels, N.Y. Harbor, N.Y	94,217,172	942,172
Lower Machodoc Creek, Va	6,972	10
Lower Thoroughfare at or near Wenona, Deal Island, Md	1,127	1
Lubec Channel, Maine	78,810	138
Lynnhaven Roads, Inlet, and Connecting Waters, Va	1,341	4
Machias River, Maine	872	2
Mackay Creek, N.C	100	(1)

See footnotes at end of table.

A.5.—Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	Tons	Total ton-miles (000 omitted)
ATLANTIC COAST—Continued		
Malden River, Mass	17,146	17
Manasquan River, N.J	68,333	102
Manhasset Bay, N.Y	626,069	1,878
Manokin River, Md	878	2
Mantua Creek, N.J	256,345	256
Matawan Creek, N.J.[2]		
Mattaponi River, Va	27,359	394
Maurice River, N.J	6,491	45
Meherrin River, N.C	5,095	53
Menemsha Creek, Marthas Vineyard, Mass	160	(1)
Merrimack River, Mass.[2]		
Miami River, Fla	268,455	1,204
Mianus River and Cos Cob Harbor, Conn	14,459	20
Middle River and Dark Head Creek, Md	1,204	4
Milford Haven, Va	3,137	3
Mill Creek, Md	56	(1)
Mill Creek, Va.[2]		
Mingo Creek, S.C.[2]		
Mispillion River, Del	23,710	285
Moriches Inlet, N.Y.[2]		
Mulberry Creek, Va	1,230	1
Murderkill River, Del	80	(1)
Mystic River, Conn	7	(1)
Mystic River, Mass	4,896,225	4,667
Nandua Creek, Va	120	(1)
Nansemond River, Va	575,090	4,773
Nanticoke River (including Northwest Fork), Del., and Md	346,458	13,553
Narraguagus River, Maine	3,416	5
Narrows of Lake Champlain, N.Y. and Vt	1,272,506	17,014
Neale Sound, Md	1,196	2
Neponset River, Mass	1	(1)
Neuse River, N.C	358,788	7,570
New Jersey Intracoastal Waterway	162,931	978
New River, Fla	3,445	8
New York and New Jersey Channels, N.Y., and N.J	110,575,960	1,735,077
New York State Barge Canal System, N.Y	3,270,796	379,412
Newark Bay, N.J	24,871,845	99,031
Newport News Creek, Va	266,730	107
Newtown Creek, N.Y	7,176,937	21,531
Nomini Bay and Creek, Va	7,791	23
Northeast (Cape Fear) River, N.C	297,154	7,429
Northeast River, Md	402	2
Occohannock Creek, Va	656	3

See footnotes at end of table.

A.5.—Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	Tons	Total ton-miles (000 omitted)
ATLANTIC COAST—Continued		
Occoquan Creek, Va	401,280	1,686
Ocmulgee River, Ga[2]		
Oconee River, Ga[2]		
Ocracoke Inlet, N.C	5,722	10
Oklawaha River, Fla	371	4
Oldmans Creek, N.J[2]		
Onancock River, Va	49,945	275
Orowoc Creek, N.Y	9,183	11
Otter Creek, Vt.[2]		
Oyster Channel, Va	18,239	16
Pagan River, Va	24,435	98
Palm Beach, Fla., side channel and basin[2]		
Pamlico and Tar Rivers, N.C	120,342	4,399
Pamunkey River, Va	9,947	20
Parish Creek, Md	4,331	3
Parker Creek, Va	143	1
Parrotts Creek, Va	3,901	3
Passaic River, N.J	10,455,266	72,724
Patchogue River, N.Y	302,827	227
Patchogue River, Westbrook, Conn	73	(1)
Patuxent River, Md	130,300	877
Pawcatuck River, R.I., and Conn.[2]		
Peconic Bay and River, N.Y	2,483	5
Penobscot River, Maine	1,587,249	40,872
Perquimans River, N.C	5,399	69
Piscataqua River, Maine, and N.H	1,654,508	(3)
Pleasant River, Maine	373	2
Pocomoke River, Md	70,307	1,600
Potomac River below Washington, D.C	5,263,037	5,263
Potomac River, Virginia Channel, D.C	538,000	2,260
Potomac River, Washington Channel, D.C	60	(1)
Quinby Creek, Va	6,554	5
Raccoon Creek, N.J	3,035	27
Rahway River, N.J	123,102	283
Rancocas River, N.J.[2]		
Rappahannock River, Va	246,173	13,319
Raritan River, N.J	10,427,656	50,498
Raritan River to Arthur Kill Cut-Off Channel, N.J	5,309,861	5,310
Rhodes Point to Tylerton, Somerset County, Md	122	(1)
Rice Creek, Fla	121,392	486
Roanoke River, N.C	404,696	8,284
Rollinson Channel, N.C	8,841	27
Royal River, Maine	1,346	2
Russell Creek, S.C.[2]		

See footnotes at end of table.

A.5.—Project Waterways, Commerce Reported for Calendar Year 1965—Continuned

Waterway	*Tons*	*Total ton-miles (000 omitted)*
ATLANTIC COAST—Continued		
Saco River, Maine	79	(1)
St. Catherines Sound, Md	1,577	23
St. Croix River, Maine	13,002	46
St. Jeromes Creek, Md	1,076	2
St. Johns River, Fla., Jacksonville to Lake Harney	1,083,714	101,890
St. Jones River, Del[2]		
St. Lucie Inlet, Fla	1,561	4
St. Marys River, Ga., and Fla	156,456	939
St. Patricks Creek, Md	4,726	4
St. Peters Creek, Md	20	(1)
Sakonnet River and Harbor, R.I.[2]		
Salem River, N.J	7,617	30
Sandy Hook Bay at Leonardo, N.J.[2]		
Sandy Hook Bay, N.J.[2]		
Santee River, S.C.	3,025	1
Satilla River, Ga.[2]		
Savannah River below Augusta, Ga	59,983	11,757
Scarboro River, Maine	178	(1)
Schuylkill River, Pa	12,549,465	50,198
Scuppernong River, N.C.	60,464	302
Seekonk River, R.I.	114,432	229
Shallotte River, N.C	1,686	5
Shark River, N.J.[2]		
Sheepshead Bay, N.Y	175,602	53
Shinnecock Inlet, N.Y.	1,143	2
Shipyard River, S.C	665,250	665
Shoal Harbor and Compton Creek, N.J.	26,629	7
Shrewsbury River, N.J	4,480	27
Slaughter Creek, Md	619	2
Smith Creek, Md	1,041	2
Smiths Creek (Pamlico County), N.C	1,150	1
Smiths Creek (Wilmington), N.C	6,925	21
Smyrna River, Del	94	1
South River, N.C	2,423	7
Starlings Creek, Va	17,102	10
Stumpy Point Bay, N.C	1,311	2
Susquehanna River above and below Havre de Grace, Md	28,213	175
Swift Creek, N.C.[2]		
Tangier Channel, Va	2,984	4
Taunton River, Mass.[2]		
Thames River, Conn	738,094	11,278
Toms River, N.J[2]		
Totuskey Creek, Va	34,501	190

See footnotes at end of table.

A.5.—Project Waterways, Commerce Repoited for Calendar Year 1965—Continued

Waterway	Tons	Total ton-miles (000 omitted)
ATLANTIC COAST—Continued		
Town Creek, Md	1,253	1
Town River, Mass	955,399	717
Tred Avon River, Md	85,414	769
Trent River, N.C	8	(1)
Tuckerton Creek, N.J	3,641	11
Twitch Cove and Big Thoroughfare River, Md	5,787	29
Tyaskin Creek, Md	16	(1)
Union River, Maine[2]		
Upper Bay, New York Harbor, N.Y., and N.J	131,354,428	732,188
Upper Machodoc Creek, Va	145	(1)
Upper Thoroughfare, Deal Island, Md	3,766	2
Urbanna Creek, Va	21,194	11
Waccamaw River, N C. and S.C	22,113	918
Wallabout Channel, N.Y	157,650	32
Wallace Channel, Pamlico Sound, N.C[2]		
Wappinger Creek, N.Y[2]		
Warren River R.I	559	1
Warwick River, Md	14,425	22
Washington Canal and South River, N.J	100,535	91
Waterway connecting Pamlico Sound and Beaufort Harbor, N.C	4,781	626
Waterway connecting Swan Quarter Bay with Deep Bay, N.C	1,070	3
Waterway from Indian River Inlet to Rehoboth Bay, Del[2]		
Waterway on the Coast of Virginia	86,725	1,376
Waycake Creek, N.J[2]		
Westchester Creek, N.Y	702,198	1,404
Weymouth Back River, Mass	28,453	14
Weymouth Fore River, Mass	2,711,526	15,225
Whitings Creek, Va	6	(1)
Wicomico River, Md. (Eastern Shore)	681,519	20,334
Willoughby Channel, Va[2]		
Wilmington Harbor, N.C. (see also Port of Wilmington, N.C., foi port data)	4,742,108	112,894
Woodbridge Creek, N.J	16,755	2
Woodbury Creek, N.J[2]		
Woods Hole Channel, Mass	51,425	46
Wrights Creek, N.C	133	(1)
York River, Va	4,366,865	100,438
GULF COAST		
Alabama-Coosa Rivers, Ala., and Ga	1,013,863	58,145

See footnotes at end of table.

A.5.—Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
GULF COAST—Continued		
Amite River and Bayou Manchac, La.[2]		
Anahuac Channel, Tex	368,938	1,845
Anclote River, Fla	672	6
Apalachicola, Chattahoochee and Flint Rivers, Ga., and Fla	415,494	43,340
Atchafalaya River, La., Morgan City to Gulf of Mexico	4,749,507	156,064
Barataria Bay Waterway, La	4,032,571	76,443
Bayous:		
Bastrop, Tex	44,076	441
Bernard, Miss	12,074	84
Big Pigeon and Little Pigeon, La	172,125	2,404
Bonfouca, La	26,195	236
Casotte, Miss	5,169,022	21,112
Cedar, Tex	294,783	1,478
Chico, Fla	96,701	140
Chocolate, Tex	2,052,213	19,290
Coden, Ala	829	1
Dickinson, Tex	572,908	6,875
Double, Tex	39,906	163
Dupre, La	188,059	419
Galere, Miss[2]		
Grosse Tete, La	1,283	31
Johnsons, La	228,429	1,142
LaBatre, Ala	67,062	199
LaGrange, Fla	97,671	396
LaLoutre, St. Malo, and Yscloskey, La	129,142	388
Lacombe, La	64,686	323
Lafourche, La	2,341,886	27,729
Little Caillou, La	97,734	1,986
Petit Anse, Tigre, and Carlin, La	1,221,167	9,210
Plaquemine Brule, La	78,775	1,497
Queue de Tortue, La[2]		
Segnette Waterway, La	95,669	193
Teche, La	704,244	42,984
Terrebonne, La	714,946	10,566
Vermilion, La	923,832	18,418
Watson, Fla	100,426	115
Black Warrior, Warrior, and Tombigbee Rivers, Ala	7,796,391	2,064,326
Blackwater River, Fla	60,158	690
Bluff Creek, Miss.[2]		
Bon Secour River, Ala	4,523	13
Brazos Island Harbor, Tex. (Waterway)	4,876,713	76,091
Calcasieu River and Pass, La	14,469,783	248,522

See footnotes at end of table.

A.5.—Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
GULF COAST—Continued		
Channel from Naples to Gordon Pass and Big Marco Pass, Fla	3,979	16
Channel to Aransas Pass, Tex	79,970	341
Channel to Palacios, Tex	321,539	4,501
Channel to Port Bolivar, Tex[2]		
Channel to Rockport, Tex	1,743	5
Chefuncte and Bogue Falia Rivers, La	110,876	965
Chickasaw Creek, Ala	780,533	1,387
Choctawhatchee River, Fla., and Ala.[2]		
Clear Creek, Tex	338,630	4,388
Clearwater Pass, Fla.[2]		
Crystal River, Fla	2,522	23
Cypress Bayou and Waterway between Jefferson, Tex., and Shreveport, La	171	1
East Pass Channel from the Gulf of Mexico into Choctawhatchee Bay, Fla	552	1
East Pearl River, Miss	234,092	4,158
Escambia and Conecuh Rivers, Fla., and Ala., Escambia Bay, Fla	637,587	13,461
Franklin Canal, La	1,537	8
Grand Bayou Pass, La.[2]		
Guadalupe River to Victoria, Tex	961,106	18,949
Gulf County Canal, Fla	167,884	854
Gulf Intracoastal Waterway:		
Between Apalachee Bay, Fla., and the Mexican Border	78,537,344	11,890,618
Morgan City—Port Allen Route	9,425,938	567,343
Homosassa River, Fla	518	3
Hudson River, Fla	74	(1)
Innerharbor Navigation Canal, La	8,325,948	30,073
Intracoastal Waterway, Caloosahatchee River to Anclote River, Fla	225,489	7,106
Kissimmee River, Fla	895	1
Lake Charles Deep Water Channel, La.[5]	26,970,353	672,058
Little Manatee River, Fla	1,530	6
Manatee River, Fla	47,702	381
Matagorda Ship Channel, Tex	4,597,167	75,977
Mermentau River, La	1,189,369	34,551
Mermentau River, Bayou Nezpique and Bayou Des Cannes, La	2,180,760	66,517
Okeechobee Waterway, Fla	294,261	9,622
Ozona, Fla., channel and turning basin[2]		
Pascagoula River, Miss.[2]		
Pass Manchac, La	153,562	1,075

See footnotes at end of table.

A-5. Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
GULF COAST—Continued		
Pearl River, Miss., and La	548,527	17,904
Pithlachascotee River, Fla	207	1
Port Aransas—Corpus Christi Waterway, Tex	29,928,314	435,068
Port Mansfield, Tex. (Tributary)	183,510	1,087
Sabine-Neches Waterway, Tex	75,286,841	1,498,011
St. Marks River, Fla	626,592	6,792
San Bernard River, Tex	1,029,030	25,093
Steinhatchee River, Fla	631	3
Suwannee River, Fla	586	5
Terrebonne Bay, La.[2]		
Three Mile Creek, Ala	4,911,079	1,722
Tickfaw, Natalbany, Ponchatoula, and Blood Rivers, La	386	3,088
Tributary Arroyo Colorado, Tex	316,109	7,705
Trinity River, Channel to Liberty, Tex	304,653	3,318
Upper Chipola River, Fla., from mouth to Marianna[2]		
Vinton Waterway, La	36,899	369
Waterway connecting the Tombigbee and Tennessee Rivers, Ala., and Miss	165,633	7,593
Waterway from Empire, La., to Gulf of Mexico	827,677	7,389
Waterway from Intracoastal Waterway to Bayou Dulac, La. (Bayous LeCarpe and Grand Caillou)	448,857	5,905
Watson Bayou, Fla	100,426	115
Withlacoochee River, Fla	65,115	591
Wolf and Jordan Rivers, Miss	54,725	656
PACIFIC COAST		
Chetco River, Oreg	184,484	74
Chinook Channel, Wash	382	(1)
Clatskanie River, Oreg	63,949	234
Columbia River:		
Mouth to International Boundary (net)	26,363,216	2,147,999
At Baker Bay, Wash	116,254	647
Columbia and Lower Willamette Rivers below Vancouver, Wash., and Portland, Oreg	27,603,143	1,699,009
Between Wenatchee and Kettle Falls, Wash	300,714	5,432
Vancouver, Wash., To the Dalles, Oreg	4,602,150	209,175
Columbia River and tributaries above The Dalles Dam, Wash., and Oreg., to McNary Lock and Dam, Oreg., and Wash	1,835,704	181,243
Columbia River and tributaries above McNary Lock and Dam to Kennewick, Wash	1,514,125	58,967
Columbia Slough, Oreg	770	1

See footnotes at end of table.

A–5. Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
PACIFIC COAST—Continued		
Coos and Millicoma Rivers, Oreg	1,098,106	7,846
Coquille River, Oreg., Bandon to Myrtle Point	456,849	1,114
Coquille River, Oreg., (entrance)	317,569	318
Cowlitz River, Wash	148,632	650
Coyote Hill Slough, Calif.[2]		
Deep River, Wash	452,601	1,646
Dry Pass, Alaska[2]		
Egegik River, Alaska[2]		
Elokomin Slough, Wash	201,470	403
Feather River, Calif.[2]		
Flathead Lake, Montana[2]		
Gastineau Channel, Alaska[2]		
Grays River, Wash	1,905	2
Hoquiam River, Wash	625,915	1,135
Kootenai River, Idaho and Montana[2]		
Lake River, Wash	52,831	100
Lake Washington Ship Canal, Wash	2,140,924	(3)
Lewis River, Wash	193,039	1,323
Middle River and connecting channels, Calif	483	(1)
Mission Bay, Calif.[2]		
Mokelumne River, Calif	65,100	580
Multnomah Channel, Oreg	715,640	3,435
Naknek River, Alaska	79,564	637
Napa River, Calif	146,497	1,238
Nehalem Bay, Oreg.[2]		
Noyo River, Calif	3,982	4
Old River, Calif	108,726	2,779
Petaluma River, Calif	342,053	3,428
Quillayute River, Wash	1,014	1
Rogue River, Oreg	81,405	82
Sacramento Deep Water Ship Channel, Calif	2,126,691	89,910
Sacramento River, Calif	2,459,819	136,955
San Joaquin River, Calif	4,987,633	128,404
San Pablo Bay and Mare Island Strait, Calif	20,394,297	233,340
San Rafael Creek, Calif.[2]		
Siuslaw River, Oreg	129,429	1,565
Skagit River, Wash	11,221	135
Skamokawa (Steamboat Slough), Wash[2]		
Skamokawa Creek, Wash	6,957	7
Skipanon Channel, Oreg	248,265	256
Smith River, Oreg	271,499	4,274
Snake River, Oreg., Wash., and Idaho	606,266	3,290
Stikine River, Alaska[2]		
Stillaguamish River, Wash	14,603	87

See footnotes at end of table.

A-5. Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
PACIFIC COAST—Continued		
Suisun Bay Channel, Calif	9,718,757	97,865
Suisun Channel, Calif	175,016	2,275
Swinomish Slough, Wash	399,566	2,668
Umpqua River, Oreg	636,843	4,653
Waterway connecting Port Townsend Bay and Oak Bay, Wash	592,559	593
Westport Slough, Oreg	282,346	288
Willamette River above Portland and Yamhill River, Oreg	4,455,550	60,134
Wrangell Narrows, Alaska	160,066	3,851
Yaquina River, Oreg	659,568	3,144
Youngs Bay and Youngs River, Oreg	623,250	1,073
GREAT LAKES		
Calumet-Sag Channel, Ill	5,274,286	119,912
Channels in Lake St. Clair, Mich	107,115,077	(6)
Chicago River (Main and North Branch), Ill	3,325,777	13,303
Chicago River, (South Branch), Ill	4,619,646	16,222
Chicago Sanitary and Ship Canal, Ill	20,109,654	343,540
Detroit River, Mich	124,458,327	3,460,501
Fox River, Wis.[2]		
Grays Reef Passage, Mich	7,697,356	(3)
Keweenaw Waterway, Mich	465,480	(3)
Lake Calumet, Ill	1,097,477	(3)
Niagara River, N.Y	2,250,871	(3)
Rouge River, Mich	13,420,201	(3)
Saginaw River, Mich	7,003,601	(3)
St. Clair River, Mich	107,015,723	4,129,301
St. Joseph River, Mich[2]		
St. Marys River, Mich	81,342,387	4,958,506
Sturgeon Bay and Lake Michigan Ship Canal, Wis	330,132	(3)
MISSISSIPPI RIVER SYSTEM		
Allegheny River, Pa., improved portion	5,351,161	63,659
Allegheny River, Pa., open channel portion	118,400	118
Arkansas River, Ark., and Okla	1,310,483	10,590
Atchafalaya River, La	4,533,609	463,615
Bayous:		
Bartholomew, La., and Ark.[2]		
D'Arbonne and Corney, La.[2]		
Big Sandy River, Tug and Levisa Forks, Ky, and W. Va	836,916	3,284

See footnotes at end of table.

A-5. Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
MISSISSIPPI RIVER SYSTEM—Continued		
Big Sunflower River, Miss	3,531	4
Black River, Ark., and Mo.[2]		
Black River, Wis	293,974	416
Boeuf River, La.[2]		
Cumberland River, mouth to Burnside, Ky. (net)	3,025,668	453,318
Mouth to Nashville, Tenn	2,988,268	447,039
Nashville, Tenn., to Burnside, Ky	163,975	6,278
French Broad and Little Pigeon Rivers, Tenn	70,215	702
Green and Barren Rivers, Ky	11,309,727	1,029,532
Illinois and Mississippi Canal, Ill.[2]		
Illinois River, Ill	27,213,135	5,424,837
Kanawha River, W. Va	13,175,358	706,459
Kentucky River, Ky	318,831	21,099
Little Kanawah River, W. Va	201,473	568
Little River, La.[2]		
Little Sunflower, River, Miss	5,369	107
Minnesota River, Minn	2,207,908	29,247
Mississippi River:		
Minneapolis, Minn., to mouth of Passes (net)	176,152,441	60,025,237
Minneapolis, Minn., to mouth of Missouri River	37,841,593	6,197,566
Mouth of Missouri River to mouth of Ohio River	41,532,117	6,300,865
Mouth of Ohio River to but not including Baton Rouge, La	59,837,435	33,517,582
Baton Rouge, La., to but not including New Orleans, La	80,778,152	6,309,098
New Orleans, La., to mouth of Passes	112,011,827	7,700,127
Mississippi River—Gulf Outlet, La	2,091,888	99,642
Missouri River:		
Fort Benton, Mont., to the mouth (net)	7,725,898	1,013,945
Kansas City to the mouth	5,592,277	783,530
Omaha to Kansas City	2,698,790	217,334
Sioux City to Omaha	573,652	12,246
Fort Benton to Sioux City	139,000	834
Monongahela River, Pa., and W. Va	38,818,615	1,789,998
Mouth of Yazoo River, Miss	895,129	3,044
Muskingum River, Ohio	41,143	8
Ohio River, Pittsburgh to Mouth	103,173,852	23,274,912
Ouachita and Black Rivers, Ark., and La	313,603	43,696
Ouachita River above Camden, Ark.[2]		
Red River below Fulton, Ark	310,122	7,009
Rough River, Ky.[2]		
St. Croix River, Wis., and Minn	13,236	304

See footnotes at end of table.

A-5. Project Waterways, Commerce Reported for Calendar Year 1965—Continued

Waterway	*Tons*	*Total ton-miles (000 omitted)*
MISSISSIPPI RIVER SYSTEM—Continued		
St. Francis and L'Anguille Rivers and Blackfish Bayou, Ark	200	12
Saline River, Ark.[2]		
Steele and Washington Bayous and Lake Washington, Miss.[2]		
Tallahatchie and Coldwater Rivers, Miss.[2]		
Tennessee River, Tenn., Ala., and Ky	17,395,855	2,190,077
Tensas River and Bayou Macon, La.[2]		
Tradewater River, Ky.[2]		
Upper White River, Ark	48,100	144
White River, Ark. below Batesville, Ark	879,251	23,611
Wolf River, Tenn	954,126	2,033
Yazoo River, Miss	182,877	4,205
Youghiogheny River, Pa	28,400	6

[1] Less than 500 ton-miles.
[2] No commerce reported.
[3] Ton-miles not reported.
[4] Included in Delaware River Philadelphia, Pa., to the sea.
Included in Gulf Intracoastal Waterway between Apalachee Bay, Fla., and the Mexican Border.
[56] Included in St. Clair River.

A–6. Navigation Locks and Dams Operable June 30, 1966 [1 2]

Name of project	*Miles above mouth*	*Community in vicinity*
Allegheny River, Pa. and N.Y.:		
Lock and dam No. 2	6.7	Aspinwall, Pa
Lock and dam No. 3	14.5	Cheswick, Pa
Lock and dam No. 4	24.2	Natrona, Pa
Lock and dam No. 5	30.4	Freeport, Pa
Lock and dam No. 6	36.3	Clinton, Pa
Lock and dam No. 7	45.7	Kittanning, Pa
Lock and dam No. 8	52.6	Templetonk Pa
Lock and dam No. 9	62.2	Rimerton, Pa
Apalachicola, Chattahoochee, and Flint Rivers, Ga., Ala., & Fla.,:		
Jim Woodruff lock and dam 4	107.6	Chattahoochee, Fla
Columbia lock and dam	154.3	Columbia, Ga
Walter F. George lock & dam[3]	182.8	Ft. Gaines, Ga
Atlantic Intracoastal Waterway:		
Albemarle and Chesapeake Canal[4] Route: Great Bridge lock	[5]11.5	Great Bridge, Va
Dismal Swamp Canal Route:		
Deep Creek lock	[5]10.6	Deep Creek, Va
South Mills lock	[5]33.2	South Mills, N.C
Bayou Teche, La.:		
Berwick lock	[7]1.5	Berwick, La
Keystone lock	[7]82.5	New Iberia, La
Black Rock Channel and Tonawanda Harbor, N.Y.: Black Rock lock	0.0	Buffalo, N.Y
Black Warrior, Warrior, and Tombigbee Rivers, Ala.:		
Jackson lock and dam	116.7	Coffeeville, Ala
Demopolis lock and dam	213.4	Demopolis, Ala
Warrior lock and dam	261.1	Eutaw, Ala
Wm. Bacon Oliver lock & dam	338.2	Tuscaloosa, Ala
Holt lock and dam	347.0	Holt, Ala
Lock and dam No. 15	357.8	Northport, Ala
Lock and dam No. 16	364.0	Adger, Ala
John Hollis Bankhead lock and dam	365.5	do
Canaveral Harbor, Fla.: Canaveral lock	2.7	Cocoa, Fla
Cape Fear River, N.C.:		
Lock and dam No. 1	67.0	Kings Bluff, N.C
Lock and dam No. 2	99.0	Browns Landing, N.C
William O. Huske lock and dam	123.0	Tolars Landing, N.C

See footnotes at end of table.

Locks (feet)					Dams		Calendar year completed	Impoundment		
Width of Chamber	Available length for full width	Lift at normal pool level	Depth on miter sills: Upper	Depth on miter sills: Lower	Type[3]	Length (feet)		Length (miles)	Authorized channel: Depth (feet)	Authorized channel: Width (feet)
56	360	11	19	11	Fixed	1,393	1934	7.8	9	200
56	360	13	12	11	-----do---	1,436	1934	9.7	9	200
56	360	10	9	10	-----do---	876	1927	6.2	9	200
56	360	12	10	11	-----do---	780	1927	5.9	9	200
56	360	12	11	11	-----do---	1,140	1928	9.4	9	200
56	360	13	11	10	-----do---	916	1931	6.9	9	200
56	360	18	14	10	-----do---	984	1937	9.6	9	200
56	360	22	11	11	-----do---	950	1938	9.8	9	200
82	450	33	14	14	Movable	5,924	1957	46.7	6	100
82	450	25	19	13	-----do---	620	1963	28.5	6	100
82	450	88	18	13	-----do---	13,371	1963	85.0	6	100
75	600	3	[6]16	[6]16	None	--------	1932	------	12	90
52	300	12	[6]12	[6]12	-----do---	--------	1940	22.0	10	100
52	300	12	[6]12	[6]13	-----do---	--------	1941	------	9	50
45	300	[8]7	[6]9	[6]9	-----do---	--------	1951	------	8	80
36	160	8	8	8	Movable	175	1913	34.5	6	50
68	625	5	22	22	None	--------	1914	3.3	21	200
110	600	34	13	13	Movable	1,175	1961	96.7	9	200
110	600	40	13	13	Fixed	1,485	1956	47.7	9	200
110	600	22	13	13	Movable	1,832	1957	77.1	9	200
95	460	28	11	11	Fixed	700	1940	9.4	9	200
110	600	67	19	13	Movable	1,138	1966	18.5	9	200
52	282	14	10	10	Fixed	870	1910	6.2	9	200
52	286	21	10	10	-----do---	1,075	1915	1.5	9	200
52	286	72	10	10	-----do---	1,170	1915	42.3	9	200
52	286	72	10	10	----------	--------	------	------	-----	-----
90	600	3	14	14	----------	--------	1965	------	12	125
40	200	11	9	9	Fixed	275	1934	32.0	8	100
40	200	9	12	12	-----do---	229	1917	24.0	8	100
40	300	9	9	9	-----do---	220	1935	20.0	8	100

A-6. Navigation Locks and Dams Operable June 30, 1966 [1] [2]—Continued.

Name of project	*Miles above mouth*	*Community in vicinity*
Columbia River, Oreg. & Wash.:		
Bonneville lock and dam[4]	145.3	Bonneville, Oreg
The Dalles lock and dam[4]	192.8	The Dalles, Oreg
McNary lock and dam[4]	292.0	Umatilla, Oreg
Cumberland River, Ky. and Tenn.:		
Barkley Dam[4]	30.6	Kuttawa, Ky
Cheatham lock and dam[4]	148.7	Ashland City, Tenn
Old Hickory lock and dam[4]	216.2	Old Hickory, Tenn
Fox River, Wis:		
DePere lock	7.1	DePere, Wis
DePere Dam	7.2	do
Little Kaukauna lock	13.0	do
Little Kaukauna Dam	13.1	do
Rapide Croche lock	19.2	Wrightstown, Wis
Rapide Croche Dam	19.3	do
Kaukauna Fifth lock	22.8	Kaukauna, Wis
Kaukauna Fourth lock	23.1	do
Kaukauna Third lock	23.3	do
Kaukauna Second lock	23.4	do
Kaukauna First lock	23.6	do
Kaukauna Dam	24.0	do
Kaukauna guard lock	24.0	do
Little Chute combined lock:		
Lower	25.4	Little Chute, Wis
Upper	25.4	do
Little Chute Second lock	26.4	do
Little Chute First (guard) lock	26.5	do
Little Chute Dam	26.6	do
Cedars lock	27.3	do
Cedars Dam	27.4	do
Appleton Fourth lock	30.7	Appleton, Wis
Appleton Lower Dam	30.9	do
Appleton Third lock	31.3	do
Appleton Second lock	31.6	do
Appleton First lock	31.9	do
Appleton Upper Dam	32.2	do
Menasha lock	37.0	Menasha, Wis
Menasha Dam	37.8	do
Green and Barren Rivers, Ky.:		
Green River:		
Lock and dam No. 1	9.1	Spottsville, Ky

See footnotes at end of table.

Locks (feet)					Dams		Calendar year completed	Impoundment		
Width of Chamber	Available length for full width	Lift at normal pool level	Depth on miter sills: Upper	Depth on miter sills: Lower	Type[3]	Length (feet)		Length (miles)	Authorized channel: Depth (feet)	Authorized channel: Width (feet)
76	500	65	32	24	Movable	2,680	1937	47.5	27	300
86	675	88	20	18	do	8,735	1957	25.0	14	250
86	675	92	20	12	do	7,600	1953	64.0	14	250
110	800	57	24	13	do	9,959	1964	118.1	9	150
110	800	26	17	17	do	801	1959	67.5	9	150
84	400	60	17	13	do	3,605	1957	97.3	9	150
36	146	9	10	12	------	------	1936	5.9	6	100
------	------	------	------	------	Movable	986	1929	------	------	------
36	146	7	8	10	------	------	1938	6.2	6	100
------	------	------	------	------	Movable	588	1926	------	------	------
36	146	8	9	9	------	------	1934	3.6	6	100
------	------	------	------	------	Movable	461	1930	------	------	------
36	144	9	7	7	------	------	1898	0.3	6	100
37	144	10	7	6	------	------	1879	0.2	6	100
37	144	10	7	6	------	------	1879	0.1	6	100
35	144	10	6	6	------	------	1903	0.2	6	100
35	144	11	7	6	------	------	1883	0.4	6	100
------	------	------	------	------	Movable	603	1931	------	------	------
40	------	------	9	------	------	------	1891	1.4	6	100
35	147	11	6	9	------	------	1879	------	6	100
36	144	11	8	6	------	------	1879	1.0	6	100
35	144	14	8	6	------	------	1881	0.1	6	100
35	------	------	7	------	------	------	1904	0.8	6	100
------	------	------	------	------	Movable	562	1932	------	------	------
35	144	10	7	7	------	------	1888	3.4	6	100
------	------	------	------	------	Movable	654	1933	------	------	------
35	144	8	8	8	------	------	1907	0.6	6	100
------	------	------	------	------	Movable	549	1934	------	------	------
35	144	9	6	9	------	------	1900	0.3	6	100
35	145	10	7	6	------	------	1901	0.3	6	100
35	145	10	7	6	------	------	1884	5.1	6	100
------	------	------	------	------	Movalbe	691	1940	------	------	------
35	144	8	7	8	------	------	1899	44.0	6	100
------	------	------	------	------	Movable	401	1937	------	------	------
84	600	12	12	11	Fixed	482	1956	54.0	9	200

A-6. Navigation Locks and Dams Operable June 30, 1966[1 2]—Continued.

Name of project	*Miles above mouth*	*Community in vicinity*
Lock and dam No. 2	63.1	Calhoun, Ky
Lock and dam No. 3	108.5	Rochester, Ky
Lock and dam No. 4[9]	149.0	Woodbury, Ky
Barren River: Lock and dam 1[11]	15.0	Greencastle, Ky
Gulf Intracoastal Waterway:		
Inner Harbor Navigation Canal lock	2.9	New Orleans, La
Harvey lock	[11]3.3	Harvey, La
Algiers lock	[11]7.0	Algiers, La
Bayou Boeuf lock	[11]96.6	Morgan City, La
Bayou Sorrel lock	[11]131.0	Plaquemine, La
Port Allen lock	[11]132.5	Port Allen, La
Vermilion lock	[11]161.5	Abbeville, La
Calcasieu lock	[11]238.5	Lake Charles, La
Colorado River, Tex	[11]441.5	Matagorda, Tex
East lock		
West lock		
Hudson River, N.Y.: Troy lock and dam	153.8	Troy, N.Y
Ice Harbor lock and dam[4]	9.7	Pasco, Wash
Illinois Waterway, Ill.:		
LaGrange lock and dam	80.2	Beardstown, Ill
Peoria lock and dam	157.7	Peoria, Ill
Starved Rock lock and dam	231.0	Utica, Ill
Marseilles lock	244.6	Marseilles, Ill
Marseilles dam	247.0	do
Dresden Island lock and dam	271.5	Morris, Ill
Brandon Road lock and dam	286.0	Joliet, Ill
Lockport lock	291.1	Lockport, Ill
Thomas J. O'Brien lock & dam	326.5	Chicago, Ill
Kanawha River, W.Va.:		
Winfield lock and dam	31.1	Winfield (Red House), W.Va.
Marmet lock and dam	67.8	Marmet (Belle), W.Va
London lock and dam	82.8	London, W. Va
Kentucky River, Ky.:		
Lock and dam No. 1	4.0	Carrolton, Ky
Lock and dam No. 2	31.0	Lockport, Ky
Lock and dam No. 3	42.0	Gest, Ky

See footnotes at end of table.

Locks (feet)					Dams		Calendar year completed	Impoundment		
Width of Chamber	Available length for full width	Lift at normal pool level	Depth on miter sills		Type[3]	Length (feet)		Length (miles)	Authorized channel	
			Upper	Lower					Depth (feet)	Width (feet)
84	600	14	15	12	do	519	1956	45.4	9	200
36	138	17	7	6	do	353	1836	40.5	6	200
35	138	16	7	7	do	409	1839	19.1	6	200
56	360	15	12	9	do	276	1934	15.1	6	200
75	640	[8]9	[6]32	[6]32	None	------	1923	------	12	150
75	425	[8]10	[6]12	[6]12	do	------	1935	------	12	125
75	800	[8]10	[6]13	[6]13	do	------	1956	------	16	150
75	1,156	[8]6	[6]13	[6]13	do	------	1956	------	16	150
56	797	[8]10	[6]14	[6]14	do	------	1952	------	12	125
84	1,202	45	[6]14	[6]14	do	------	1961	------	12	125
56	1,182	[8]3	[6]11	[6]11	do	------	1934	------	16	200
75	1,206	[8]6	[6]13	[6]13	do	------	1950	------	16	200
------	------	------	------	------	do	------	1954	------	12	125
75	1,200	[8]5	[6]15	[6]15	------	------	------	------	------	------
75	1,200	[8]5	[6]15	[6]15	------	------	------	------	------	------
44	493	17	16	13	Fixed	1,495	1917	2.2	1	400
86	675	100	18	19	Movable	2,790	1962	31.9	14	250
110	600	10	16	13	do	1,066	1939	77.5	9	300
110	600	11	16	12	do	536	1939	73.3	9	300
110	600	19	17	14	do	1,280	1933	13.6	9	300
110	600	24	19	14	------	------	1933	26.9	9	300
------	------	------	------	------	Movable	819	1933	24.6	------	------
110	600	22	17	12	do	1,616	1933	14.5	9	300
110	600	34	18	14	Movable	2,391	1933	5.1	9	300
110	600	40	12	15	None	------	1933	34.5	9	300
110	1,000	2	14	14	Movable	257	1960	6.9	9	300
56	360	28	18	12	do	834	1937	36.7	9	300
56	360	28	18	12	------	------	------	------	------	------
56	360	24	18	12	do	707	1934	15.0	9	300
56	360	24	18	12	------	------	------	------	------	------
56	360	24	18	12	do	707	1934	7.8	9	300
56	360	24	18	12	------	------	------	------	------	------
38	145	8	8	15	Fixed	424	1839	27.0	6	100
38	145	14	8	6	do	400	1839	11.0	6	100
38	145	13	9	7	do	465	1844	23.0	6	100

A-6. Navigation Locks and Dams Operable June 30, 1966[1] [2]—Continued.

Name of project	*Miles above mouth*	*Community in vicinity*
Lock and dam No. 4	65.0	Frankfort, Ky
Lock and dam No. 5	82.2	Tyrone, Ky
Lock and dam No. 6	96.2	High Bridge, Ky
Lock and dam No. 7	117.0	do
Lock and dam No. 8	139.9	Camp Nelson, Ky
Lock and dam No. 9	157.5	Valley View, Ky
Lock and dam No. 10	176.4	Ford, Ky
Lock and dam No. 11	201.0	Irvine, Ky
Lock and dam No. 12	220.9	Ravenna, Ky
Lock and dam No. 13	239.9	Willow, Ky
Lock and dam No. 14	249.0	Heidelberg, Ky
Lake Washington ship canal:		
Hiram M. Chittenden locks:		
Large lock	1.3	Seattle, Wash
Small lock		
Mississippi River between Ohio and Missouri Rivers: Locks and dam No. 27	[12]185.1	Granite City, Ill
Mississippi River between Missouri River & Minneapolis, Minn.:		
Locks and dam No. 26	202.9	Alton, Ill
Lock and dam No. 25	241.4	Cap Au Gris, Mo
Lock and dam No. 24	273.4	Clarksville, Mo
Lock and dam No. 22	301.2	Saverton, Mo
Lock and dam No. 21	324.9	Quincy, Ill
Lock and dam No. 20	343.2	Canton, Mo
Lock and dam No. 19	364.2	Keokuk, Iowa
Lock and dam No. 18	410.5	Burlington, Iowa
Lock and dam No. 17	437.1	New Boston, Ill
Lock and dam No. 16	457.2	Muscatine, Iowa
Lock and dam No. 15	482.9	Rock Island, Ill
Lock and dam No. 14	493.1	Le Claire, Iowa
	493.3	do
Lock and dam No. 13	522.5	Clinton, Iowa
Lock and dam No. 12	556.7	Bellevue, Iowa
Lock and dam No. 11	583.0	Dubuque, Iowa

See footnotes at end of table.

Locks (feet)					Dams		Calendar year completed	Impoundment		
Width of Chamber	Available length for full width	Lift at normal pool level	Depth on miter sills		Type[3]	Length (feet)		Length (miles)	Authorized channel	
			Upper	Lower					Depth (feet)	Width (feet)
38	145	13	6	6	-----do---	543	1844	17.2	6	100
38	145	15	10	6	-----do---	556	1844	14.0	6	100
52	147	14	9	6	-----do---	413	1891	20.8	6	100
52	147	15	9	7	-----do---	350	1897	22.9	6	100
52	146	19	11	6	-----do---	257	1900	17.6	6	100
52	148	17	11	7	-----do---	362	1907	18.9	6	100
52	148	17	9	6	-----do---	472	1907	24.6	6	100
52	148	18	10	6	-----do---	208	1906	19.9	6	100
52	148	17	10	6	-----do---	240	1910	19.0	6	100
52	148	18	10	6	-----do---	248	1915	9.1	6	100
52	148	17	9	6	-----do---	248	1917	9.6	6	100
80	760	25	36	29	Movable	235	1916	17.0	34	150
28	123	25	16	16	----------	--------	------	------	-----	-----
110	1,200	[13]21	16	15	Fixed	3,240	1963	17.8	9	200
110	600	[13]21	16	15	----------	--------	------	------	-----	-----
110	600	24	19	10	Movable	1,725	[1]1938	38.5	9	200
110	360	24	16	10	----------	--------	------	------	-----	-----
110	600	15	19	12	-----do---	1,296	1939	32.0	9	200
110	600	15	19	12	-----do---	4,280	1940	27.8	9	200
110	600	10	18	14	-----do---	1,024	1938	23.7	9	Not specified
110	600	10	17	12	-----do---	1,066	1938	18.3	9	
110	600	10	15	12	-----do---	2,144	1936	21.0	Same for waterway through lock and dam 1.	
110	358	38	14	9	Fixed	4,434	1913	46.3		
110	1,200	38	15	13	----------	--------	1957	------		
110	600	10	17	14	Movable	1,350	1937	26.6		
100	600	8	16	13	-----do---	921	1939	20.1		
110	600	9	17	12	-----do---	1,099	1937	25.7		
110	600	16	27	11	-----do---	1,203	1934	10.4		
110	360	16	27	11	----------	--------	------	------		
80	320	11	18	11	----------	--------	1922	------		
110	600	11	21	11	Movable	1,343	1939	29.2		
110	600	11	19	13	-----do---	1,066	1939	34.2		
110	600	9	17	13	-----do---	849	1939	26.3		
110	600	11	19	13	-----do---	1,278	1937	32.1		

A-6. Navigation Locks and Dams Operable June 30, 1966[1] [2]—Continued

Name of project	*Miles above mouth*	*Community in vicinity*
Lock and dam No. 10	615.1	Guttenberg, Iowa
Lock and dam No. 9	647.9	Lynxville, Wis
Lock and dam No. 8	679.2	Genoa, Wis
Lock and dam No. 7	702.5	Dresbach, Minn
Lock and dam No. 6	714.3	Trempealeau, Wis
Lock and dam No. 5A	728.5	Winona, Minn
Lock and dam No. 5	738.1	Minneiska, Minn
Lock and dam No. 4	752.8	Alma, Wis
Lock and dam No. 3	796.9	Red Wing, Minn
Lock and dam No. 2	815.2	Hastings, Minn
Lock and dam No. 1	847.6	Minneapolis-St. Paul
St. Anthony Falls lower lock and dam	853.3	Minneapolis, Minn
St. Anthony Falls upper lock and dam	853.9	do
Monongahela River, W. Va. & Pa.:		
Locks and dam No. 2	11.2	Braddock, Pa
Locks and dam No. 3	23.8	Elizabeth, Pa
Locks and dam No. 4	41.5	Charleroi, Pa
Locks and dam No. 5	56.5	Brownsville, Pa
Maxwell locks and dam	61.2	Maxwell, Pa
Lock and dam No. 7	85.0	Greensboro, Pa
Lock and dam No. 8	90.8	Point Marion, Pa
Morgantown lock and dam	102.0	Morgantown, W. Va
Hildebrand lock and dam	108.0	do
Lock and dam No. 14	115.3	Lowsville, W. Va
Lock and dam No. 15	124.6	Hoult, W. Va
Ohio River:		
Lock and dam No. 53	18.4	Mound City, Ill
Lock and dam No. 52	42.1	Brookport, Ill
Lock and dam No. 51	77.9	Golconda, Ill
Lock and dam No. 50	104.2	Weston, Ky
Lock and dam No. 49	136.0	Uniontown, Ky

See footnotes at end of table.

Locks (feet)					*Dams*		*Calendar year completed*	*Impoundment*		
Width of Chamber	*Available length for full width*	*Lift at normal pool level*	*Depth on miter sills*		*Type*[3]	*Length (feet)*		*Length (miles)*	*Authorized channel*	
			Upper	*Lower*					*Depth (feet)*	*Width (feet)*
110	600	8	15	12	-----do---	763	1936	32.8		
110	600	9	16	13	-----do---	811	1938	31.3		
110	600	11	22	14	-----do---	897	1937	23.3		
110	600	8	18	12	-----do---	940	1937	11.8		
110	600	6	17	13	-----do---	893	1936	14.2		
110	600	5	18	13	-----do---	682	1936	9.6		
110	600	9	18	12	-----do---	1,619	1935	14.7		
110	600	7	17	13	-----do---	1,367	1935	44.1		
110	600	8	17	14	-----do---	365	1938	18.3		
110	600	12	22	13	Movable	822	1930	32.4		
110	500	12	16	15	----------	--------	1948	------		
56	400	36	13	8	Fixed	574	1932	5.7		
56	400	36	13	10	----------	--------	1917	------		
56	400	27	14	10	Movable	188	1959	.5	9	100
56	400	49	16	14	Fixed	3,584	1963	3.8	9	100
56	360	9	16	16	-----do---	748	1951	12.6	9	125
110	720	9	16	16	----------	--------	1953	------	-----	-----
56	360	8	12	12	Fixed	688	1907	17.7	9	125
56	720	8	12	12	----------	--------	1907	------	-----	-----
56	360	11	14	11	Fixed	553	1932	15.0	9	125
56	720	11	14	11	----------	--------	1932	------	-----	-----
56	360	12	12	11	Fixed	555	1909	4.7	9	125
56	360	12	12	11	----------	--------	1909	------	-----	-----
84	720	20	21	15	Movable	460	1965	23.8	9	125
84	720	20	21	15	----------	--------	1965	------	-----	-----
56	360	15	11	10	Fixed	610	1926	5.8	9	125
56	360	19	11	10	Movable	560	1959	11.2	9	125
84	600	17	18	15	-----do---	410	1950	6.0	9	125
84	600	21	9	9	-----do---	530	1960	7.3	9	125
56	182	11	7	7	Fixed	446	1903	9.3	9	125
56	182	11	7	7	-----do---	430	1903	4.1	7	125
									9	300
110	600	13	15	10	Movable	3,978	1929	23.7	Same for	
110	600	12	15	11	-----do---	3,073	1928	35.8	entire	
110	600	8	15	11	-----do---	2,445	1929	26.3	length of	
110	600	10	17	11	-----do---	2,630	1928	31.8	waterway	
110	600	11	17	13	Movable	1,542	1928	35.4	9	300

A-6. Navigation Locks and Dams Operable June 30, 1966[1 2]—Continued.

Name of project	*Miles above mouth*	*Community in vicinity*
Lock and dam No. 48	171.4	Henderson, Ky
Lock and dam No. 47	203.3	Newburgh, Ind
Lock and dam No. 46	223.7	Owensboro, Ky
Lock and dam No. 45	278.0	Addison, Ky
Lock and dam No. 44	317.8	Leavenworth, Ind
Lock and dam No. 43	347.8	West Point ,Ky
McAlpind locks and dam	374.2	Lousiville, Ky
Markland locks and dam	449.5	Markland, Ind
Captain Anthony Meldahl locks and dam	544.8	Foster, Ky
Greenup locks and dam	640.0	Greenup, Ky
Gallipolis locks and dam	701.8	Hogsett, W. Va
Lock and dam No. 23	749.6	Millwood, W. Va
Lock and dam No. 22	760.1	Ravenswood, W. Va
Lock and dam No. 21	766.4	Portland, Ohio
Lock and dam No. 20	778.5	Belleville, W. Va
Lock and dam No. 19	788.8	Little Hocking, Ohio
Lock and dam No. 18	801.1	Parkersburg, W. Va
Lock and dam No. 17	813.5	Marietta, Ohio
Lock and dam No. 16	834.5	Bens Run, W. Va
Lock and dam No. 15	851.9	New Martinsville, W. Va
Lock and dam No. 14	867.0	Woodland, W. Va
Lock and dam No. 13	884.9	McMechen, W. Va
Lock and dam No. 12	893.6	Warwood, W. Va
Pike Island locks and dam	896.7	Warwood, W. Va
New Cumberland locks and dam	926.6	Stratton, Ohio
Montgomery Island locks and dam	949.3	Industry, Pa
Dashields locks and dam	967.7	Sewickley, Pa

See footnotes at end of table.

Locks (feet)					Dams		Calendar year completed	Impoundment		
			Depth on miter sills						Authorized channel	
Width of Chamber	Available length for full width	Lift at normal pool level	Upper	Lower	Type[3]	Length (feet)		Length (miles)	Depth (feet)	Width (feet)
110	600	7	15	13	-----do---	2,320	1922	31.9	Same for entire length of waterway	
110	600	9	15	11	-----do---	2,045	1928	20.4		
110	600	11	17	11	-----do---	2,520	1928	54.3		
110	600	9	17	13	-----do---	1,460	1927	39.8		
110	600	7	15	13	-----do---	1,460	1925	30.0		
110	600	9	15	11	-----do---	1,538	1921	26.4		
110	1,200	37	49	12	-----do---	8,627	1961	75.3		
110	600	37	19	11	----------	--------	1921	------		
56	360	37	19	11	----------	--------	1930	------		
110	1,200	35	50	15	Movable	1,395	1963	95.3		
110	600	35	50	15	----------	--------	1963	------		
110	1,200	30	18	15	Movable	1,756	1962	95.2		
110	600	30	18	15	----------	--------	1962	------		
110	600	30	18	13	-----do---	1,287	1962	61.8		
110	1,200	30	18	13	----------	--------	------	------		
110	360	26	18	12	Movable	1,116	1937	47.8		
110	600	26	18	12	----------	--------	------	------		
110	600	6	15	14	Movable	1,012	1921	10.5		
110	600	8	15	11	-----do---	1,044	1918	6.3		
110	600	6	15	11	-----do---	1,088	1919	12.1		
110	600	7	15	11	-----do---	1,012	1917	10.3		
110	600	8	17	11	-----do---	1,212	1916	12.3		
110	600	6	14	11	-----do---	1,135	1910	12.4		
110	600	8	15	11	-----do---	1,272	1918	21.0		
110	600	8	15	11	-----do---	980	1917	17.4		
110	600	8	15	11	-----do---	1,028	1916	15.1		
110	600	8	16	11	-----do---	956	1917	17.9		
110	600	7	14	10	-----do---	996	1911	8.7		
110	600	8	15	11	-----do---	1,20	1916	3.1		
110	1,200	21	17	15	Movable	1,306	1963	29.9		
110	600	21	17	15	----------	--------	1963	------		
110	600	23	19	13	-----do---	1,315	1961	22.7		
110	1,200	23	19	13	----------	--------	------	------		
56	360	18	16	13	Movable	1,379	1936	18.4		
110	600	18	16	13	----------	--------	------	------		
56	360	10	13	18	Fixed	1,585	1929	7.1		
110	600	10	13	18	----------	--------	------	------		

A-6. Navigation Locks and Dams Operable June 30, 1966[1] [2]—Continued.

Name of project	*Miles above mouth*	*Community in vicinity*
Emsworth locks and dam	974.8	Emsworth, Pa
Okeechobee Waterway, Fla.:		
St. Lucie lock and dam	15.1	Stuart, Fla
Moore Haven lock	78.0	Moore Haven, Fla
Ortona lock and dam	93.6	LaBelle, Fla
Structure 79	121.4	Fort Myers, Fla
Oklawaha River, Fla.: Moss Bluff lock and dam	65.5	Ocala, Fla
Old River, La	[15]301.8	Simmesport, La
Ouachita and Black Rivers, Ark. and La.:		
Lock and dam No. 2	57.6	Harrisonburg, La
Lock and dam No. 3	118.3	Riverton, La
Lock and dam No. 4	162.4	Monroe, La
Lock and dam No. 5	192.6	Sterlington Reach, La
Lock and dam No. 6	223.0	Felsenthal, Ark
Lock and dam No. 8	281.8	Calion, Ark
Pearl River, Miss. and La.:		
Lock 1	29.4	Pearl River, La
Lock 2	40.7	Bush, La
Lock 3	43.9	Sun, La
Sacramento River (Barge Canal lock)	42.8	West Sacramento, Calif
St. Marys River, Mich.:		
South Canal: MacArthur lock	47.0	Sault Ste. Marie, Mich
North Canal:		
Davis lock	47.0	do
Sabin lock	47.0	do
Savannah River, Ga.: Lock and dam	203.0	Augusta, Ga
Tennessee River, Tenn., Ala., Miss., and Ky.[16]		
Kentucky lock and dam	22.4	Gilbertsville, Ky

See footnotes at end of table.

Locks (feet)					Dams		Calendar year completed	Impoundment		
			Depth on miter sills						Authorized channel	
Width of Chamber	Available length for full width	Lift at normal pool level	Upper	Lower	Type[3]	Length (feet)		Length (miles)	Depth (feet)	Width (feet)
56	360	18	17	13	Movable	1,717	1921	6.2		
110	600	18	17	13	----------	--------	------	------		
50	250	13	14	12	Movable	170	1941	15.1	8	80
50	250	2	10	11	None	--------	1953	15.6	8	90
50	250	11	12	11	Movable	104	1937	15.6	8	90
56	400	3	13	------	-----do---	1,150	1965	7.9	8	90
30	125	11	9	5	-----do---	54	1925	------	(14)	Not specified
75	1,200	35	18	14	None	--------	1963	------	12	125
------	------	------	------	------	----------	--------	------	------	6.5	100
55	268	15	21	6	Movable	377	1921	60.7	Channel completed to depth of 6.5 ft. Authorized in 1960 to depth of 9 ft.	
55	268	15	21	7	-----do---	399	1920	44.1		
55	268	9	15	7	-----do---	411	1922	30.2		
55	268	7	14	7	-----do---	311	1926	30.4		
55	268	10	14	7	-----do---	314	1923	58.8		
55	268	14	16	7	-----do---	306	1926	53.5		
65	310	17	10	10	None	--------	1951	11.3	7	80
65	310	15	10	10	-----do---	--------	1951	3.2	7	80
65	310	11	10	10	-----do---	--------	1951	13.3	7	80
86	600	4	13	13	None	--------	1961	1.5	13	120
------	------	------	------	------	----------	--------	------	------	------	------
------	------	------	------	------	----------	--------	------	------	27	Not specified
80	800	22	31	31	None	--------	1943	------	------	------
80	1,350	22	24	23	-----do---	--------	1914	------	------	------
80	1,350	22	24	23	-----do---	--------	1919	------	------	------
56	360	15	14	12	Movable	363	1936	16.2	9	90
------	------	------	------	------	----------	--------	------	------	9	300

A-6. Navigation Locks and Dams Operable June 30, 1966[1 2]—Continued.

Name of project	*Miles above mouth*	*Community in vicinity*
Pickwick Landing lock & dam	206.7	Hamburg, Tenn
Wilson lock and dam	259.4	Florence, Ala
(Upper lift)		do
(Lower lift)		do
General Joe Wheeler lock and dam	274.9	do
Guntersville lock and dam	349.0	Guntersville, Ala
Hales Bar lock and dam	431.1	Chattanooga, Tenn
Chickamauga lock and dam	4790	do
Watts Bar lock and dam	529.9	Breedenton, Tenn
Fort Loudoun lock and dam	602.3	Lenoir City, Tenn
Melton Hill lock and dam (Clinch River)	23.1	Kingston, Tenn
Willamette River at Willamette Falls, Oreg.:		
Lock No. 1	26.0	Oregon City, Oreg
Lock No. 2	26.0	do
Lock No. 3	26.0	do
Lock No. 4	26.0	do
Guard lock	26.4	Oregon City, Oreg

Total number of locks—236, including 28 auxiliary locks and 2 guard, locks.

Total number of dams—154, including 9 multiple-purpose dams. Excludes 10 dams listed which are operated by Tennessee Valley Authority

[1] Additional detail is in vol. 2, 1966 Annual Report.

[2] Bridge clearances set forth in Corps of Engineers publications "Bridges over Navigable Waters of the United States."

[3] Fixed crest without gates or other facility to control streamflow. Movable dam includes any type of crest gates, such as tainter gates, wickets, and others to control streamflow.

[4] Additional detail is in appendix C-2, vol. 1, 1965 Annual Report.

[5] Miles from Norfolk ,Va.

[6] Depth is that normally prevailing with reference to mean low water.

[7] Miles from Gulf Intracosatal Waterway.

[8] Average high and low water conditions, lift varying widely dependent on tides and river stages.

Locks (feet)					*Dams*		*Calendar year completed*	*Impoundment*		
Width of Chamber	*Available length for full width*	*Lift at normal pool level*	*Depth on miter sills*		*Type*[8]	*Length (feet)*		*Length (miles)*	*Authorized channel*	
			Upper	*Lower*					*Depth (feet)*	*Width (feet)*
110	600	57	11	13	-----do---	7,976	1944	184.3	Same for length of waterway from mouth through Fort Loudoun L&D	
110	600	55	10	13	-----do---	7,385	1937	52.7		
110	600	94	13	13	-----do---	3,728	1959	15.5		
60	292	47	11	11	----------	--------	1927	------		
60	300	47	11	11	----------	--------	1927	------		
60	400	48	15	13	Movable	5,738	1962	74.1	----------	
60	360	39	13	12	Movable	3,837	1939	82.1	Same for length of waterway from mouth through Fort Loudoun L&D	
60	265	39	17	11	-----do---	1,423	1948	39.9		
60	360	49	10	14	-----do---	5,654	1940	58.9		
60	360	58	12	12	-----do---	2,646	1942	72.4		
60	360	72	12	12	-----do---	0,687	1943	49.8		
75	400	54	13	13	-----do---	906	1963	38.2	9	[17]
37	175	20	6	8	None	--------	1872	------	8	150
37	175	10	6	8	-----do---	--------	1872	------	-----	-----
37	175	10	6	8	-----do---	--------	1872	------	-----	-----
37	175	10	6	8	-----do---	--------	1872	.4	-----	-----
38	175	10	6	8	None	--------	1872	23.6	6	Not specified.

[9] Inoperable; dam failed May 24, 1965.
[10] Pool maintained for small boat use; navigation through lock suspended because of loss of lower pool.
[11] Miles from New Orleans, La.
[12] Miles above the Ohio River.
[13] Maximum head at minimum pool and tailwater based of flow of 25.000 cubic feet per second.
[14] 6-foot depth from mouth of river to Silver Springs Run. about 57.7 miles; 4-foot depth there from to Leesburg. about 33.4 miles.
[15] Miles above the Head of Passes.
[16] Tennessee River locks operated by the Corps, dams operated by Tennessee Valley Authority.
[17] Width of channel 300 feet from lock to mouth of Clinch River and 175 feet upstream from lock to Clinton, Tenn.

B–1. *Reservoirs of the Corps Providing Flood Control as of June 30, 1966*

(Storage in thousands of acre-feet. Only flood control storage is shown.)

Region	Completed or in partial operation		Under construction not operable		Authorized, not started		Total active		Deferred	Inactive	Total of active, deferred, inactive
	No.	Storage[1]	No.	Storage	No.	Storage	No.	Storage	No.	No.	No.
Alaska											
Arkanasa-White-Red	37	23,537	11	2,556	23	5,127	71	31,220	2	4	77
Central & South Pacific	11	409			1	125	12	534		5	17
Central Valley	16	3,991	5	888	5	644	26	5,523	1		27
Colorado	6	2,351	1	370	2	259	9	2,980			9
Columbia	13	2,152	6	7,275	7	481	[2]26	[2]9,897	1		27
Great Basin	1	1	1	15	5	313	7	329	1		8
Great Lakes & St. Lawrence	5	415					5	415			5
Gulf & South Atlantic	[3]5	[3]1,923	3	347	5	1,204	13	3,474	16		29
Hawaii											
Lower Mississippi	5	4,412					5	4,412			5
Middle Atlantic	14	1,935	2	97	14	1,333	30	3,365	4		34
Missouri	26	21,217	8	5,865	17	4,359	51	31,441	4	4	59
New England	32	1,065	4	69	1	1,000	37	2,134	4	10	51
North Pacific	2	212			4	300	6	512			6
Ohio	46	10,963	18	3,447	25	3,768	89	18,178	9	10	108
Rio Grande & gulf	19	7,728	4	1,301	8	3,026	31	12,055	1	3	35
Souris & Red	4	103					4	103		2	6
Upper Mississippi	12	3,039	6	3,903	6	1,190	24	8,132	3		27
Total	254	85,452	69	26,123	123	23,129	446	134,704	46	38	530

[1] This tabulation shows maximum flood control storage. At some projects, notably the Missouri River main-stem reservoirs, and several reservoirs in the Columbia and Central Valley regions, a portion of the storage shown is used for other purposes on a seasonal basis.

[2] Three re-regulating structures, with 36,000 acre-feet of storage, are included as separate reservoirs.

[3] Region total excludes Central and Southern Florida project consisting of 21 lakes and conservation impoundments with 10,690,000 acre-feet of storage.

B–2. Flood Damages Prevented by Corps of Engineers Projects

(In Thousands of Dollars)

Region	*During fiscal year 1966*	*Cumulative through fiscal year 1966*
Alaska	$56	$2,726
Arkansas-White-Red	16,604	378,823
Central & South Pacific	48,275	337,781
Central Valley		1,069,145
Colorado	17,685	18,535
Columbia	20,719	893,919
Great Basin		950
Great Lakes & St. Lawrence	2,485	31,338
Gulf & South Atlantic	19,030	146,293
Hawaii	5	825
Lower Mississippi	263,977	7,971,738
Middle Atlantic	1,097	247,009
Missouri	105,847	1,467,948
New England	38	157,946
North Pacific	250	20,374
Ohio	47,783	1,210,981
Rio Grande & gulf	74,280	395,098
Souris & Red	1,493	11,587
Upper Mississippi	2,658	255,112
Total	622,282	14,618,128

B-3. Flood Damages Prevented During Fiscal Year 1966

(In thousands of dollars)

Memphis District	$38,935	
New Orleans District	208,940	
St. Louis District	197	
Vicksburg District	24,389	
Lower Mississippi Valley Division		$272,461
Kansas City District	104,485	
Omaha District	1,362	
Missouri River Division		105,847
New England Division		
Baltimore District	1,030	
New York District	273	
Norfolk District		
Philadelphia District		
North Atlantic Division		1,303
Buffalo District	880	
Chicago District	409	
Detroit District	873	
Rock Island District	1,627	
St. Paul District	2,415	
North Central Division		6,204
Alaska District	56	
Portland District	20,767	
Seattle District	113	
Walla Walla District	89	
North Pacific Division		21,025
Huntington District	7,817	
Louisville District	2,842	
Nashville District	5,130	
Pittsburgh District	31,994	
Ohio River Division		47,783
Honolulu District	5	
Pacific Ocean Division		5
Charleston District	576	
Jacksonville District	15,360	
Mobile District	2,126	
Savannah District	290	
Wilmington District	745	
South Atlantic Division		19,097
Los Angeles District	65,160	
Sacramento District		
San Francisco District	800	
South Pacific Division		65,960
Albuquerque District	697	
Fort Worth District	73,947	
Galveston District		
Little Rock District	5,545	
Tulsa District	2,408	
Southweatern Division		82,597
Total		622,282

B-4. Local Protection Projects Completed or in Partial Operation as of June 30, 1966

Region	Authorization: Specific	Authorization: General[1]	Total number
Alaska	5	0	5
Arkansas-White-Red	53	3	56
Central and South Pacific	15	11	26
Central Valley	10	4	14
Colorado	2	1	3
Columbia	63	7	70
Great Basin	3	1	4
Great Lakes and St. Lawrence	12	5	17
Gulf and South Atlantic	17	21	[2]38
Hawaii	1	1	2
Lower Mississippi	6	6	[3]12
Middle Atlantic	26	26	52
Missouri	64	13	77
New England	24	16	40
North Pacific	7	13	20
Ohio	69	14	83
Rio Grande and gulf	11	6	17
Souris and Red	9	1	10
Upper Mississippi	85	13	98
Total	482	162	644

[1] Includes small projects not specifically authorized by Congress, constructed under the small-project authority provided by section 205, 1948 Flood Control Act, as amended; excludes work under general authorities for snagging and clearing, emergency bank protection, and emergency repair projects.

[2] Central and Southern Florida is considered as one project.

[3] Mississippi River and tributaries is considered as one project.

APPENDIX C

HYDROPOWER

Region	*No. of projects*	*Capacity in operation on June 30, 1966 (thousand KW)*	*Generation during the fiscal year (million KWH)*
Alaska			
Arkansas-White-Red	12	1,273	2,273
Central and South Pacific			
Central Valley			
Colorado			
Columbia	10	4,262	27,002
Great Basin			
Great Lakes and St. Lawrence	1	18	162
Gulf and South Atlantic	6	864	2,240
Hawaii			
Lower Mississippi			
Middle Atlantic	2	218	262
Missouri	6	1,990	9,083
New England			
North Pacific			
Ohio	6	725	1,425
Rio Grande and gulf	2	82	42
Souris and Red			
Upper Mississippi			
Total	45	9,432	42,489

APPENDIX D

WATER SUPPLY AND IRRIGATION

D–1. Water Supply Storage as of June 30, 1966

Project	*Storage (acre-feet)*	*Local agency*
In operation		
Alatoona, Ga	13,140	Cobb County-Marietta Water Authority.
Baldhill, N. Dak	[1]69,500	Eastern North Dakota, Water Development Association.
Bardwell, Tex	42,800	Trinity River Authority.
Barren River, Ky	681	City of Glasgow, Ky.
Beaver, Ark	108,000	Beaver Water District, Ark.
Belton, Tex	12,000	Fort Hood, Tex.
Do	113,700	Brazos River Authority.
Do	247,000	Do.
Berlin, Ohio	19,400	Mahoning Valley Sanitary District.
Canton, Okla	90,000	Oklahoma City, Okla.
Canyon, Tex	366,400	Guadalupe-Blanco River Authority, Tex.
Carlyle, Ill	33,000	State of Illinois.
Clark Hill, Ga. and S.C	210	McCormick, S.C.
Do	92	Lincolnton, Ga.
Council Grove, Kans	24,400	Council Grove and Emporia, Kans.
Dam B, Tex	94,200	Lower Neches Valley Authority, Tex.
East Brimfield, Mass	1,140	American Optical Co., Mass.
Ferrells Bridge, Tex	251,100	Northeast Texas Municipal Water District.
Fort Supply, Okla	400	Oklahoma State Board of Public Affairs.
Grapevine, Tex	85,000	Dallas, Tex.
Do	50,000	Park Cities, Tex.
Do	1,250	City of Grapevine, Tex.
Heyburn, Okla	1,000	Keifer, Okla.
Do	300	Rural Water Dist. No. 1, Creek County, Okla.
Homme, N. Dak	[1]3,650	Park River and Grafton, N. Dak.
Hords Creek, Tex	5,780	Coleman, Tex.
Hulah, Okla	15,400	Bartlesville, Okla.
Do	2,000	Oil Recovery Corp., Okla.
Do	200	KWB Oil Mgt.

See footnote at end of table.

D.1. Water Supply Storage as of June 30. 1966—Continued

Project	*Storage (acre-feet)*	*Local agency*
John Redmond, Kans	34,900	State of Kansas.
Lavon, Tex	100,000	North Texas Municipal Water District.
Lake Texoma (Denison) Tex. and Okla	21,300	Denison, Tex.
Do	16,400	Texas Power and Light Co.
Do	1,150	Sinclair Oil and Gas Co.
Lewisville, Tex	415,000	Dallas, Tex.
Do	21,000	Denton, Tex.
Littleville, Mass	9,400	Springfield, Mass.
Millwood, Ark	150,000	Southwest Arkansas Water District.
Monroe, Ind	159,900	State of Indiana.
Mosquito Creek, Ohio	11,000	Warren, Ohio.
Navarro Mills, Tex	53,200	Trinity River Authority.
Oologah, Okla	38,000	Tulsa, Okla.
Do	500	Collinsville, Okla.
Do	5,000	Public Service Co. of Okla.
Do	2,500	Claremore Inc., Claremore, Okla.
Do	100	Rural Water Dist. No. 1, Nowata County, Okla.
Do	300	Rural Water Dist. No. 3, Rogers County, Okla.
Do	300	Rural Water Dist. No. 4, Rogers County, Okla.
Pomona, Kans	230	Rural Water Dist. No. 3, Kans.
Do	160	Pomona Reservoir Water Co., Kans.
Proctor, Tex	31,400	Brazos River Authority, Tex.
San Angelo, Tex	[2]80,400	Upper Colorado River Authority.
Sam Rayburn, Tex	1,383,500	Lower Neches Valley Authority.
Tenkiller Ferry, Okla	300	East Central Water Authority, Okla.
Texarkana, Tex. & Ark	[1]13,400	Cities of Texarkana, Tex. & Ark.
Tom Jenkins, Ohio	5,800	State of Ohio.
Toronto, Kans	265	City of Toronto, Kans.
Waco, Tex	[3]91,074	Brazos River Authority, Tex.
Do	13,026	Waco, Tex.
W. Kerr Scott, N.C	33,000	Winston-Salem and Wilkes Co., N.C.
Wister, Okla	1,600	Heavener Utilities Authority.
Subtotal	4,345,848	
Subtotal (rounded)	4,346,000	
Under construction		
Beltzville, Pa	27,900	Delaware River Basin Commission.
Bowman-Haley, N. Dak	16,000	Bowman County Water Management District.
Broken Bow, Okla	153,000	State of Oklahoma.

D-1. Water Supply Storage as of June 30, 1966—Continued

Project	*Storage (acre-feet)*	*Local agency*
Brookville, Ind	89,300	State of Indiana.
Clarence Cannon Dam & Mo	20,000	Missouri Water Resources Board
Colebrook, Reservoir, Conn	30,700	City of Hartford, Conn.
Cooper Reservoir, Tex	240,900	City of Irving, Sulphur River Water District, North Texas Municipal Water District, Texas Water Development Board.
DeGary, Ark	238,730	Ouachita River Water District, Ark.
DeQueen, Ark	17,900	Tri-Lakes Water District, Ark.
Elk City, Reservoir, Kans	42,300	State of Kansas.
Gillham, Ark	28,700	Tri-Lakes Water District, Ark.
Kaw, Okla	[4] 232,000	City of Ponca, Okla. Water Resources Board.
Milford, Kans	300,000	State of Kansas.
Okatibbee, Miss	13,500	Pat Harrison Waterway District, Hattiesburg, Miss.
Optima, Okla	76,200	Oklahoma Water Resources Board.
Pat Mayse, Tex	87,700	City of Paris, Tex.
Perry Kans	150,000	State of Kansas.
Pine Creek, Okla	70,000	Mountain Lakes Water District.
Rend Lake, Ill	109,000	State of Illinois.
Shelbyville, Ill	25,000	State of Illinois.
Somerville, Tex	143,900	Brazos River Authority.
Stillhouse Hollow, Tex	204,900	Brazos River Authority.
West Branch, Ohio	52,900	Mahoning & Trunbull Counties.
Subtotal	2,370,530	
Subtotal (rounded)	2,371,000	
Total	6,716,378	
Total (rounded)	6,716,000	

[1] Seasonal for flood control and water supply.
[2] Water supply and power storage combined.
[3] Exchange storage for existing storage in Lake Waco.
[4] Joint water supply, water quality control, and recreation pool of 232,000 acre-feet.

D-2. Irrigation Storage as of June 30, 1966

(In thousands of acre-feet)

Project	*Exclusive irrigation storage*	*Joint-use storage*
In Operation		
Black Butte, Calif		150
Conchas, N. Mex	275	
Cottage Grove, Oreg		30
Cougar, Oreg		155
Detroit, Oreg		300
Dorena, Oreg		70
Fall Creek, Oreg		115
Fern Ridge, Oreg		94
Folsom, Calif		910
Harlan County, Nebr	150	
Hills Creek, Oreg		200
Isabella, Calif		535
John Martin, Colo	367	
Lake Mendocino, Calif		70
Lookout Point, Oreg		337
Lucky Peak, Idaho		280
New Hogan, Calif	145	165
Pine Flat, Calif		1,000
Success, Calif		75
Terminus, Calif		142
Total	937	4,628
Under construction		
Blue River, Oreg		75
Green Peter, Oreg		300
Total		375

APPENDIX E

GENERAL

E-1. Directory of Installations and Activities

A. Division and Districts:

U.S. Army Engineer Division, Lower Mississippi Valley, Post Office Box 80, Vicksburg, Miss., 39180

- U.S. Army Engineer District, Memphis, 668 Federal Office Building, Memphis, Tenn., 38103
- U.S. Army Engineer District, New Orleans, Post Office Box 60267, New Orleans, La., 70160
- U.S. Army Engineer District, St. Louis, 906 Olive Street, St. Louis, Mo., 63101
- U.S. Army Engineer District, Vicksburg, Post Office Box 60, Vicksburg, Miss., 39180

U.S. Army Engineer Division, Missouri River, Post Office Box 103, Downtown Station, Omaha, Nebr., 68101

- U.S. Army Engineer District, Kansas City, 700 Federal Office Building, 601 East 12th Street, Kansas City, Mo., 64106
- U.S. Army Engineer District, Omaha, 6012 U.S. Post Office and Court House, 215 North 17th Street, Omaha, Nebr., 68102

U.S. Army Engineer Division, New England, 424 Trapelo Road, Waltham, Mass., 02154

U.S. Army Engineer Division, North Atlantic, 90 Church Street, New York, New York, 10007

- U.S. Army Engineer District, Baltimore, Post Office Box 1715, Baltimore, Md., 21203
- U.S. Army Engineer District, New York, 111 East 16th Street, New York, N.Y., 10003
- U.S. Army Engineer District, Norfolk, Fort Norfolk, 803 Front Street, Norfolk, Va., 23510
- U.S. Army Engineer District, Philadelphia, Custom House, 2d and Chestnut Streets, Philadelphia, Pa., 19106

U.S. Army Engineer Division, North Central, 536 South Clark Street, Chicago, Ill., 60605

U.S. Army Engineer District, Buffalo, Foot of Bridge Street, Buffalo, N.Y., 14207

U.S. Army Engineer District, Chicago, 219 S. Dearborn Street, Chicago, Ill., 60604

U.S. Army Engineer District, Detroit, Post Office Box 1027, Detroit, Mich., 48231

U.S. Army Engineer District, Rock Island, Clock Tower Building, Rock Island, Ill., 61201

U.S. Army Engineer District, St. Paul, 1217 U.S. Post Office and Customhouse, St. Paul, Minn., 55101

U.S. Army Engineer District, Lake Survey, 630 Federal Building, Detroit, Mich., 48226

U.S. Army Engineer Division, North Pacific, 210 Custom House, Portland, Oreg., 97209

U.S. Army Engineer District, Alaska, Post Office Box 7002, Anchorage, Alaska, 99501

U.S. Army Engineer District, Portland, 628 Pittock Block, Portland, Oreg., 97205

U.S. Army Engineer District, Seattle, 1519 Alaskan Way, South, Seattle, Wash., 98134

U.S. Army Engineer District, Walla Walla, Building 602, City-County Airport, Walla Walla, Wash., 99362

U.S. Army Engineer Division, Ohio River, Post Office Box 1159, Cincinnati, Ohio, 45201

U.S. Army Engineer District, Huntington, Post Office Box 2127, Huntington, W.Va., 25721

U.S. Army Engineer District, Louisville, Post Office Box 59, Louisville, Kentucky, 40201

U.S. Army Engineer District, Nashville, Post Office Box 1070, Nashville, Tenn., 37202

U.S. Army Engineer District, Pittsburgh, 2032 Federal Building, 1000 Liberty Avenue, Pittsburgh, Pa., 15222

U.S. Army Engineer Division, Pacific Ocean, Building 96, Fort Armstrong, Honolulu, Hawaii, 96813

U.S. Army Engineer District, Honolulu, Building 96, Fort Armstrong, Honolulu, Hawaii, 96813

U.S. Army Engineer Division, South Atlantic, 510 Title Building, 30 Pryor Street, S.W., Atlanta, Georgia, 30303

U.S. Army Engineer District, Charleston, Post Office Box 905, Charleston, S.C., 29402

U.S. Army Engineer District, Jacksonville, Post Office Box 4970, Jacksonville, Fla., 32201

U.S. Army Engineer District, Mobile, Post Office Box 1169, Mobile, Ala., 36601

U.S. Army Engineer District, Savannah, Post Office Box 889, Savannah, Ga., 31402

U.S. Army Engineer District, Wilmington, Post Office Box 1890, Wilmington, N.C., 28401

U.S. Army Engineer Division, South Pacific, 630 Sansome Street, Room 1216, San Francisco, Calif., 94111

U.S. Army Engineer District, Los Angeles, Post Office Box 2711, Los Angeles, Calif., 90053

U.S. Army Engineer District, Sacramento, 650 Capitol Mall, Sacramento, Calif., 95814

U.S. Army Engineer District, San Francisco, 100 McAllister Street, San Francisco, Calif., 94102

U.S. Army Engineer Division, Southwestern, 1114 Commerce Street, Dallas, Tex., 75202

U.S. Army Engineer District, Albuquerque, Post Office Box 1580, Albuquerque, N. Mex., 87103

U.S. Army Engineer District, Fort Worth, Post Office Box 17300 Fort Worth, Tex., 76102

U.S. Army Engineer District, Galveston, Post Office Box 1229, Galveston, Tex., 77550

U.S. Army Engineer District, Little Rock, Post Office Box 867, Little Rock, Ark., 72203

U.S. Army Engineer District, Tulsa, Post Office Box 61, Tulsa, Okla., 74102

B. Boards, Commissions, and Stations:

Board of Engineers for Rivers and Harbors, Tempo C Building, 2d and Q Streets, S.W., Washington, D.C., 20315

California Debris Commission, 650 Capitol Mall, Sacramento, Calif., 95814

Mississippi River Commission, Post Office Box 80, Vicksburg, Miss., 39180

U.S. Army Coastal Engineering Research Board, 5201 Little Falls Road, N.W., Washington, D.C., 20016

U.S. Army Engineer Waterways Experiment Station, Post Office Box 631, Vicksburg, Miss., 39180

C. International Boards and Commissions:

International Boundary and Water Commission, United States

and Mexico; Secretary, U.S. Section, Louis F. Blanchard, P.O. Box 1859, El Paso, Tex., 79950

International Joint Commission, United States and Canada; Secretary, U.S. Section, William A. Bullard, Room 208, 1711 New York Avenue, N.W., Washington, D.C., 20006

Columbia River Treaty Permanent Engineering Board, United States and Canada; Secretary, U.S. Section, John W. Roche, Office, Chief of Engineers, U.S. Army Washington, D.C., 20315

International Champlain Waterway Board, United States and Canada; Secretary, U.S. Section, John W. Roche, Office, Chief of Engineers, U.S. Army, Washington, D.C., 20315

International Great Lakes Levels Board, United States and Canada; Secretary, U.S. Section, John W. Roche, Office, Chief of Engineers, U.S. Army, Washington, D.C., 20315

International Pembina River Engineering Board, United States and Canada; Secretary, U.S. Section, Leon Maca, Department of the Interior, Washington, D.C., 20240

International St. Croix River Engineering Board, United States and Canada; Secretary, U.S. Section, John W. Roche, Office, Chief of Engineers, U.S. Army, Washington, D.C., 20315

International Saint John River Engineering Board, United States and Canada; Secretary, U.S. Section, J. A. Bettendorf, Geological Survey, Department of the Interior, Washington, D.C., 20240

E-2. *Reservoirs of the Corps of Engineers on June 30, 1966*

(Storage in thousands of acre-feet. Total storage is shown)

Region	*Completed or in partial operation*		*Under construction not operable*		*Authorized, not started*		*Total active*		*Deferred*	*Inactive*	*Total of active, inactive*
	No.	*Storage*[1]	*No.*	*Storage*	*No.*	*Storage*	*No.*	*Storage*	*No.*	*No.*	*No.*
Alaska					2	570	2	570			2
Arkansas-White-Red	38	48,336	14	6,086	23	7,032	75	61,454	2	4	81
Central & South Pacific	11	489			1	277	12	766		5	17
Central Valley	[1]16	[1]7,610	5	4,108	5	3,255	26	14,973	1		27
Colorado	6	2,562	1	1,043	2	464	9	4,069			9
Columbia	18	6,472	9	13,948	9	1,017	[2]36	[2]21,437	1		37
Great Basin	1	1	1	15	5	344	7	360	1		8
Great Lakes & St. Lawrence	5	452					5	452			5
Gulf & South Atlantic	[3]7	[3]10,437	5	1,946	5	2,688	17	15,071	16		33
Hawaii											
Lower Mississippi	5	4,717					5	4,717			5
Middle Atlantic	14	3,645	2	167	14	2,689	30	6,501	4		34
Missouri	26	82,706	8	8,800	17	7,963	51	99,469	4	4	59
New England	32	1,079	4	116	1	8,096	37	9,291	4	10	51
North Pacific	2	212			4	914	6	1,126			6
Ohio	48	20,451	20	6,136	25	5,307	93	31,894	10	10	113
Rio Grande & gulf	20	14,161	5	1,886	10	6,504	35	22,551	1	4	40
Souris & Red	4	229					4	229		2	6
Upper Mississippi	12	3,812	6	5,008	6	1,892	24	10,712	3		27
Total	265	207,371	80	49,259	129	49,012	474	305,642	47	39	560

[1] Excludes three debris-control structures with 89,000 acre-feet of storage.

[2] Four reregulating structures, with 98,000 acre-feet of storage, are included as separate reservoirs.

[3] Regional total excludes Central and Southern Florida project consisting of 21 lakes and conservation impoundments with 10,690,000 acre-feet of storage.

ARMY ENGINEERS PLAY MAJOR ROLE IN HURRICANE BETSY RECOVERY EFFORT

by

Colonel Thomas J. Bowen

District Engineer, U.S. Army Engineer District, New Orleans

Hurricane Betsy from its inception was a highly erratic storm until it took a bead on the southeastern Louisiana coast, when it became one of the most destructive hurricanes of the Twentieth Century.

On August 26, 1965, a tropical depression was located approximately 675 miles east, northeast of the Isle of Trinidad. The squalls that spawned this hurricane moved in a west, northwesterly direction and were identified by reconnaissance aircraft on the morning of the 27th. On that day gale warnings were issued along the Lesser Antilles and the depression was then tropical storm Betsy. By August 29th the tropical storm had developed into Hurricane Betsy with winds of 80 miles per hour.

After pursuing a rambling course that included two complete loops, on September 4 Betsy did a complete about-face in the Atlantic altering her course from north to south. Three days later Betsy stalled off the southern tip of Florida and on September 8 moved west through the Florida Keys into the Gulf of Mexico. Betsy then accelerated her forward movement to about 20 miles per hour; and on the evening of September 9, 1965, the center of the eye crossed the Louisiana coast just west of Grand Isle, La. Her wind velocity reportedly ranged from 70 to 105 miles per hour, with gusts of better than 160 miles per hour, producing tides up to 16 feet above mean set level. Betsy inundated an area of some 4,800 square miles; killed 81 persons within the State; and caused about 250,000 persons to be evacuated. Transportation, communications, and utility services were disrupted throughout the eastern coastal area of Louisiana for weeks.

At Grande Isle the tidal erosion was so extensive that the original configuration of the island was changed. The main State highway on the island was intercepted and eroded at numerous points. The tidal surge flowed entirely across the island and there was severe wind damage to buildings and utilities.

Betsy's movement filled the lower Mississippi River, as evidenced by an 8-foot rise at New Orleans in a 4-hour period and a rise as far up as St. Joseph, La., some 400 miles above Head of Passes. In addition, it built up and pushed across the lower coast the most severe tidal surge recorded in this part of Louisiana. This surge literally picked up houses and tremendous amounts of debris and deposited them on roadways and on the east bank mainline Mississippi River levees. The tidal surge, as it moved out of the Gulf of Mexico from the east, eventually topped the west levee on the Mississippi River. This overtopping of the west levee caused the flooding from Venice to near Port Sulphur, La. The back levees in this area retained the water in the populated areas, thus extending the duration of the flooding. In topping the west levees, considerable debris was pushed over the levee onto the highways and into the settled areas. This surge also caused considerable erosion of the mainline levees.

In the New Orleans area the tidal surge centered on the Industrial Canal, which connects the Mississippi River to Lake Pontchartrain. Vast areas of Orleans Parish and St. Bernard Parish were inundated by the tidal surge that accompanied the storm. This surge topped or breached the non-Federal levees protecting these areas.

Damage to maritime interests throughout the area was extensive. On the Mississippi River from Baton Rouge to the gulf, there were 144 ships, barges, tugs, and ferries beached on the levees; and another 56 vessels were reported missing. Chlorine Barge 602 was another casualty of the storm.

While well over a million Louisiana residents were still stunned by the death and destruction of Betsy, President Johnson personally inspected the State and designated Louisiana a major disaster area. Acting for the President in administration of the Federal Disaster Act, Public Law 875, 81st Congress, the Director of the Office of Emergency Planning (OEP) coordinated Federal assistance in disaster recovery, and directed provision of Public Law 875 assistance in 35 parishes (counties) determined eligible. Specified tasks were requested to be accomplished by the Corps of Engineers along with emergency work performed under statu-

tory authorities of the Chief of Engineers.

The Corps New Orleans District immediately undertook recovery work in the capacity of engineer agent for OEP. Before this, in the immediate aftermath of Betsy, New Orleans District engineer forces had acted under Corps authority and assisted in the early evacuation of over 1,200 people in the New Orleans area. Throughout the disaster area, engineer personnel started rendering assistance to local government officials. To accomplish the multitude of required operations, of which only a few are highlighted below, the New Orleans District utilized its entire workforce of 1,200, augmented by 232 skilled personnel borrowed from 28 other Engineer Districts throughout the country.

In order to appreciate fully the nature of the operations the Corps faced, one must realize that the land elevation of metropolitan New Orleans is mostly below sea level. Naturally, every drop of water that falls within the levee system must be pumped out. Betsy's tidal surge flooded the crucial pumping plants and generally inactivated them. Consequently, one task of highest priority was to reduce the water in the flooded areas so the city pumps could be placed back in service. The Corps mobilized six hydraulic dredges and two pump barges to aid in reducing the floodwaters. In addition, the Corps furnished and installed pumps at various locations in the flooded area. Three ricefield pumps, two 36-inch pumps, and one 30-inch pumps were installed and operated under a Corps contract. A number of smaller pumps were also put in operation where needed most.

In one particularly hard-hit area, the Carolyn Park Subdivision, the back levee was badly erodod on the landslide and several crevasses had occurred. Local interests, assisted by the Corps, furnished equipment and made expedient levee repairs with unselected material. The simultaneous birth of a new storm in the gulf, Hurricane Debby, subjected the area to abnormally high tides; and seepage was noted in the repaired areas. The Corps undertook the complete restoration of this segment of levee after first reinforcing the most crucial reaches of the structure.

Another major task undertaken was the debris removal from the flooded and wind-damaged public areas. Throughout the New Orleans metropolitan area there was severe tree blowdown. In the flooded areas most household possessions were discarded because of saltwater saturation, and dumped in their wet and soggy condition into the streets. This posed a monumental task of loading and hauling to disposal and burning areas. Throughout the debris

cleanup operation, 50 Corps contractors loaded and hauled over 200,000 loads of debris at a cost of about $8.5 million.

The task of removing dislocated houses from the levees and the highways presented many interesting engineer challenges. The houses had to be raised and moved without further damage, and returned to the owner's original homesite. In some areas the work area was extremely restricted, with a canal on one side of the highway and flooded marshland on the other side. In such restricted areas our contractors could reach and work on only one house at a time as the work progressed down the highway.

Two other aspects of the recovery work were the cleaning and sanitizing of schools and the demolition of buildings almost completely destroyed by Betsy and declared menaces to the public safety. One astounding act of Betsy's winds occurred at the Holy Redeemer Catholic Church where the side walls and roof were leveled, while the altar was virtually undamaged. The sanctuary candle remained burning and its glass covering was not even cracked. Originally the Corps was to complete demolition but church officials later elected to perform the work themselves.

Another interesting phenomenon of the storm occurred at the home of the Mississippi River Pilots at Pilottown, located 2 miles above the Head of Passes in the Mississippi River. The buildings in Pilottown are up on pilings and there are no front or back levees. This area was struck by the greatest intensity of Hurricane Betsy with the loss of only part of a boardwalk.

Total damages within the New Orleans District for all causes were estimated at $372 million attributable to Hurricane Betsy. Of this amount, $168 million is estimated to be total damages from tidal overflow; $50 million for wind damage exclusively; and $154 million for a combination of wind and flood losses that are inseparable. Total damages prevented by existing Federal projects amount to an estimated $70 million. The loss of an estimated $85½ million could have been prevented by authorized but not built projects.

COLUMBIA RIVER TREATY AND PACIFIC NORTHWEST-SOUTHWEST INTERTIE ACCELERATE POWERPLANT EXPANSION IN PACIFIC NORTHWEST

by

David J. Lewis

Supervisory Hydraulic Engineer, Water Control Branch,
U.S. Army Engineer Division, North Pacific Division

The Columbia River Treaty with Canada, along with the Pacific Northwest-Southwest Intertie and other related agreements, for which the treaty served as a catalyst, has propelled the Corps of Engineers into a new phase of rapid powerplant expansion in the Pacific Northwest, advancing by more than a decade the installation of generating units at existing plants which were not expected to be in operation before 1985. Two major factors combined to create the need for this immediate expansion: better regulation of the seasonal riverflows and higher peak load requirements added by the Pacific Northwest-Southwest Intertie.

The hydroelectric development of the main stem Columbia River downstream from the Canadian border will be virtually complete with the initial operation of the Corps John Day Project in the spring of 1968. Eleven projects, five of which are operated by the Corps of Engineers, will develop some 1,200 feet of the potential 1,290 feet of head. The treaty projects, through regulation of about 40 percent of the flow which originates in Canada, will more than double the storage presently available for river regulation. The resulting higher assured riverflow through this 1,200 feet head will greatly increase the power potential of the Columbia River. Realization of this potential requires a substantial increase in the generating capacity of the projects downstream as well as new operational arrangements and procedures.

COLUMBIA RIVER TREATY

For over 20 years the Corps of Engineers has been involved in

extensive study of international development of storage on the Upper Columbia River in Canada. During this time it has been represented on the International Joint Commission, the International Columbia River Engineering Board, and the treaty negotiating team.

As a result of these many years of effort, the two governments signed the Columbia River Treaty in January 1961 and cooperative development of Columbia River storage in Canada seemed assured. The treaty provided that Canada would build and operate three storage projects having a total of 15.5 million acre-feet of storage usable for developing power benefits downstream in the United States. Of this storage, 1,400,000 acre-feet would be at the Duncan project on a tributary of the Kootenay River, 7,100,000 acre-feet at the Arrow Lakes project on the Columbia River, and 7 million acre-feet at the Mica project on the Columbia River.

In return for the storage regulation provided by these projects, the United States would deliver to Canada one-half of the power benefits which would result downstream in the United States. The power would be delivered to Canada in the form of dependable capacity and annual average energy, both of which would be determined by a procedure spelled out in the Treaty and its annexes.

In addition to giving Canada one-half of the power gained, the treaty provides that the United States will pay Canada an amount aggregating $64,400,000 for anticipated flood control benefits. The appropriate part of this payment will be made at the time each of the three projects becomes operable for flood control, and entitles the United States to the use of 8,450,000 acre-feet of storage for flood regulation. The payment was computed to be the equivalent of the present worth of half the average annual flood control benefit resulting from operation of this storage until 60 years from the date of ratification of the treaty.

The United States is also entitled to the use of all other storage on the Columbia River in Canada for flood control purposes. An additional payment of $1,875,000 is to be made each time the storage is called for. However, after the fourth call there will be no additional payments. The United States will be required to compensate Canada for any power losses incurred as a result of this additional flood control regulation.

In addition to providing for Canadian construction of the three storages in Canada, the treaty permits the United States to build the Libby project on the Kootenai River with a reservoir extend-

ing 42 miles into Canada. Both countries will realize flood control and power benefits downstream from this project since the Kootenai River re-enters Canada before flowing into the Columbia River. Each country will retain all the benefits developed within its boundaries.

DELAY IN CANADIAN RATIFICATION

The treaty, which anticipated early construction of the projects, was ratified by the U.S. Senate shortly after the signing, but ratification was delayed in Canada. During the initial delay significant changes took place in Canada. A change in National Government required further negotiation for clarification of certain parts of the treaty. Simultaneously, the Province of British Columbia moved ahead with the Portage Mountain project on the Peace River in Northern British Columbia. The development of power at the Portage Mountain project would provide British Columbia with all its added power requirements for a number of years without using its share of Columbia River power. In addition, construction of the project would create a heavy capital requirement for the Province and increase its difficulty in financing the Columbia River projects.

As the delay was extended, the United States was forced to proceed with its own hydroelectric development to meet power requirements which it had anticipated would be met by early construction of the treaty storages. As a result, neither the Pacific Northwest nor British Columbia had an immediate need for the power from Canadian storage and it became apparent that early implementation of the treaty would require not only the sale of the Canadian share of power to the United States with payment in advance to provide the necessary capital for construction of the Canadian projects, but also a market for the power outside the Northwest.

PACIFIC NORTHWEST–SOUTHWEST INTERTIE

The Pacific Southwest provided an obvious market for surplus power but no intertie connected the two areas. A large capacity interconnection was required to market the initial surplus of power, but since surplus would diminish in a few years, other uses of the interconnection were explored which would justify

amortization over a longer period of time. As a result of the studies and negotiations between the Bonneville Power Administration, the Bureau of Reclamation and utilities in both the Pacific Northwest and Southwest, a plan evolved for an intertie much larger than that previously conceived and serving more purposes.

The intertie will be used to market surplus secondary energy as well as the Canadian entitlement power. It will permit diversity exchanges so that surplus winter energy in the Phoenix area can be exchanged for surplus summer energy in the Northwest and, most significantly, it will permit the marketing of peaking capacity which can be added to existing projects in the Pacific Northwest at less cost than it can be added in the Pacific Southwest.

The intertie plan that evolved from these negotiations will consist of four extra high voltage lines. Some segments of these lines will be built by Bonneville Power Administration, some by the Bureau of Reclamation, and some by five public and private utilities. The first two lines which will be completed in 1967 and 1968 will be 500 kilovolt alternating current lines connecting the Pacific Northwest transmission grid near the Corps John Day project with Los Angeles through the San Francisco area. The third line, which will be completed in 1969, will be a 750 kilovolt direct current line connecting the Pacific Northwest grid near the Corps of Engineers and The Dalles project directly with Los Angeles. The fourth line, which will be completed in 1971, will also be a 750 kilovolt direct current line and will start and terminate at the same places as the third, but will have a terminal also at Hoover Dam. In total, the four lines, will be capable of transmitting about 4,500,000 kilowatts.

SALE OF CANADIAN POWER ENTITLEMENT

At the same time arrangements were being worked out for the intertie and negotiations were proceeding with Canada for the prepaid sale of their entitlement to downstream power, other agreements were being negotiated in th United States to make the purchase possible. A tax exempt organization, the Columbia Storage Power Exchange (CSPE) was being formed to issue bonds and to make the lump sum payment to Canada. Contracts were being arranged between CSPE and utilities which would purchase power from CSPE and between the Bonneville Power Administration and the utilities for energy and capacity exchanges to make the stipulated amounts of Canadian entitlement better

suit individual utility's load-resource situations. Agreements were being reached on the amounts of power which each of the projects benefiting from Canadian storage would make available to CSPE, and to projects which sustained a loss in firm power because of the added storage. To assure each party that he would realize the benefits to which he was entitled as a participant in these arrangements, which assumed a completely coordinated storage operation, the Pacific Northwest Coordination Agreement, to which the Corps was a signator, was being prepared. Each of these arrangements was contingent on completion of all the others and in September 1964 all the parts were completed, the United States and Canada exchanged notes of ratification of the treaty and $254 million was given to Canada in payment for its entitlement to power for 30 years.

ROLE OF NORTH PACIFIC DIVISION, CORPS OF ENGINEERS

The Corps of Engineers had participated actively in the events leading to the final agreements. Collectively they have resulted in obligations of the U.S. Government which have significantly affected the program of the North Pacific Division. The 20.5 million acre-feet of treaty storage, including 5 million acre-feet at the Corps Libby project, in addition to 2 million acre-feet at the Dworshak project which is now under construction by the Corps and 2.2 million acre-feet at the High Mountain Sheep project for which the Pacific Northwest Power Co. has a license, will increase the storage usable for power regulation of the Columbia River from 13.5 million acre-feet in 1967 to 38.2 million acre-feet 7 years later in 1974.

This increased storage will permit reducing the maximum flood of record from 1,240,000 to 650,000 cubic feet per second in the lower Columbia River where the damages are greatest but will necessitate more extensive hydrometeorological data collection and flood control operating effort. It will also increase the assured riverflow for power generation and require increased generating capacity to realize the benefits of the higher flow.

The increased firm flows and the commitments for delivery of capacity to the Pacific Southwest will require that 2,700,000 kilowatts of capacity be added by 1974 at existing projects in the Northwest or to the previously scheduled installations at projects now under construction. The Bureau of Reclamation's third

powerhouse at Grand Coulee, for which construction has been authorized, cannot be in operation in time to meet this requirement and the non-Federal utilities plan to add only 600,000 kilowatts more than previously scheduled, so that the remaining 2,100,000 kilowatts must be added to Corps projects.

This 2,100,000 kilowatts will bring to approximately 6 million kilowatts the total generating capacity to be completed at Corps projects in the Pacific Northwest between 1966 and 1974. At that time about 3 million kilowatts of undeveloped capacity will remain at then existing Corps plants. The selection of an optimum schedule for adding peaking units to the system requires increasingly complex study and analysis. The installation schedule requires consideration of economic factors, the relatively usability of alternatives being considered and the impact of the use of the additional capacity on nonpower uses.

The simplest means of adding capacity at existing plants would be to complete one plant and then another, with units of the same size as those initially installed. This would result in uneconomic scheduling, however, and in hydraulic imbalances between plants which might restrict the use of capacity and hinder optimum economic development of the transmission grid.

ECONOMIC CONSIDERATIONS

The value of the energy which can be generated from otherwise spilled water by added units is as significant a factor in the economic sequence as the cost of the units. Completing the planned 27 unit Chief Joseph powerplant is estimated to have a construction cost of $82.00 per kilowatt, for example. Since the value of the energy which can be produced by the addition of 11 units to the existing 16 unit plant is greater than the cost of the additional units, they would be justified by energy alone.

The construction cost of adding capacity varies from as little as $45 per kilowatt at John Day as to high as $370 per kilowatt at Bonneville project where no provisions were made for expansion. Even so, when the utilization of spilled water is evaluated and deducted from the total cost, we find the remaining cost of adding capacity at Bonneville is less than $1.00 a kilowatt year, while the net cost of adding capacity at John Day is slightly over $1.00 a year. Bonneville's power installation is so limited that unless it is increased, the project will be spilling water more than 83 percent of the time while spill at John Day would occur about 33

percent of the time with the ten units originally planned. The Dalles project can be completed with a net capacity cost of $1.70 a kilowatt year but McNary which has no provisions for future units will have a net cost of $8.30 per kilowatt year, because of the high construction cost of over $200 a kilowatt for the new powerplant and the relatively small amount of undeveloped energy. Each unit and each combination of units in each project will have a different construction cost, generally decreasing as the number of units increases, but the incremental energy associated with each added unit also decreases as the number of units increases. Each unit, therefore, rather than each project has a unique economic position.

A computer program has been developed to examine the economics of selection of units. It uses as input data the computer output from the regular monthly system regulation studies and the incremental costs of adding units singly and in groups at each project. With this data the program examines each unit in the roughly 50 powerplants included in the system regulation and determines the net capacity cost of each. It lists individual generating units in order of their cost, starting with the units having the highest net benefit and ending with the unit having the greatest net cost.

USABILITY OF CAPACITY

The economic preference as determined by this listing must be subjected to and modified by other considerations. If the hydraulic capacity and available pondage at one plant are far in excess of the one immediately downstream, that capacity may not be usable effectively in the load. For instance, if the John Day plant's ultimate capacity of 20 units were to be completed solely on the basis of net capacity cost, while The Dalles plant downstream was left unchanged, the hydraulic capacity of John Day when fully loaded would be over 400,000 cubic feet per second and that of The Dalles about 200,000 cubic feet per second. During periods when both plants were heavily loaded the 53,000 acre-feet of storage in The Dalles pond would soon fill, necessitating either a reduced loading at John Day or spill at The Dalles. The economic loss of the spill would be unacceptable so that in either case the usefulness of the capacity would be limited. Where there is open river rather than a reservoir downstream, the change or rate of change of flows might be limited in the interest of some

nonpower use such as recreation or navigation and the use of the capacity might be so restricted as to overcome an apparent economic advantage. If the use of capacity is limited for either reason, the most effective remedy may be to increase a pool level and thereby its available pondage.

COMPUTER SIMULATION OF PEAKING OPERATION

To study the effects of future peaking operations, two computer programs have been prepared by the North Pacific Division. Each is designed to simulate hourly operation. One, which models the turbines and river in a detailed manner is limited by computer memory and speed to the simulation of about 20 projects and, therefore, requires that a part of the Northwest load be preassigned to the projects included in the model thus precluding examination as part of the total system. The other program, which generalizes by incorporating a flow travel time rather than a routing procedure and uses typical Kaplan and Francis turbine characteristics rather than unique characterisitcs for each plant, will accept the entire Columbia River system of more than 50 projects. This program is used to make detailed weekly studies of any desired combination of plant installation, load, and riverflow conditions. The flows and reservoir conditions for the selected month are taken from the monthly regulation studies and introduced to the computer along with Pacific Northwest hourly loads less an amountequal to the approximately 10 percent of the resources not included in the Columbia River regulation. The program divides the system load between the projects in a manner similar to the load frequency control system used in operating the Federal system. It then computes for each hour in the week the generation, discharge, tailwater elevation and forebay elevation of all projects in the system. With this information the effects of the operation on the river stages can be studied and it can be determined whether the capacity installed at each project can be used effectively for meeting its appropriate part of the systems load with the available pondage.

Since the Federal load at present includes a large proportion of base load it has a relatively small peaking requirement and the river fluctuations have been modest. The large new plant expansions to accomodate the peak load of the Pacific Southwest and to carry a larger proportion of the Northwest peak load will require large and rapid fluctuations in the river's flow and stages.

While computer programs have provided the means of finding the extent of these fluctuations for any particular combination of projects and generating units, very little was known of the impact on other river uses.

FIELD TESTS OF PEAKING OPERATION

Field tests were made at three of the hydroelectric projects this year in which extreme future peaking conditions were simulated by supplementing power releases with spillway releases. Extensive precautions were taken in making the tests to assure public safety. The river conditions were simulated on the computer in advance with the detailed hourly program. The public was advised by newspaper, radio, and direct notification of the conditions which would prevail. The Harbor Patrol, County Sheriff's office, and an observer in a helicopter fitted with pontoons patrolled the critical areas of the river throughout the tests. The various fisheries agencies observed the effect on the movement of fish and the navigation companies participated by moving a barge through the critical areas during the extreme conditions of change although all navigation other than the test barge were interrupted at critical points during the test period.

Two river reaches that were considered to be critical with regard to the affect of extreme peaking conditions on nonpower uses of the river were the Snake River below Ice Harbor and both the Bonneville reservoir and the Columbia River below Bonneville Dam. Field tests of Ice Harbor were conducted during August of 1965 at a time when the river was being used for recreation including swimming and water skiing. During the most extreme test at Ice Harbor the tailwater rose 10 feet in one hour and during that hour a barge was moved upstream into the lock and returned downstream. There appeared to be no seriously adverse affects from the Ice Harbor peaking operation. Because of concern for the safety of river users downstream, the Bonneville tests were delayed until March of 1966 when recreational use was limited although salmon fishing was underway from both the banks and from boats. No seriously adverse affects were noted during these tests although the results were not as conclusive as the Ice Harbor tests. Recreation was limited at the time and an unexpected storm increased the flow of the Willamette River to an unrepresentatively high level creating enough backwater affects in

some of the critical reaches below Bonneville to minimize the effects of peaking.

TRANSMISSION

Consideration of the economics and the effectiveness of a particular unit in meeting loads under all load and riverflow conditions must be supplemented by consideration of the transmission economics and system transmission conditions. The units being considered for early addition are at projects on the Columbia and Lower Snake Rivers which are adjacent to the main loop of the heavy Federal transmission grid so that except for the transmission stability requirement of 600 megawatts, additional capacity at The Dalles or John Day, transmission is not a decisive factor in scheduling units at this time.

SUMMARY

The next decade will see marked changes in the development and operation of the Columbia River hydro system. Much of this change will be expansion of existing powerplants and the lead time between engineering and on-line operation will be significantly shorter than with new projects. Planning and design time will, therefore, affect some schedules.

Studies have progressed far enough to establish reasonable schedules for adding units. Much work remains, however, on determining the optimum pool heights, in selecting the appropriate turbine characteristics, and for planning generating units in excess of some projects previously planned ultimate capacities. The studies of project modification may delay completion of otherwise desirable units but alternative units at projects requiring minimum study effort can be substituted. These substititutions will keep the total Federal capacity growth on schedule while permitting proper development of the system.

In the spring of 1968 when Duncan project is completed, the area will experience the first benefit of the 20 years of study and negotiation. The flood stage on the lower river will be reduced by storage of the spring runoff at Duncan project. Later, in the fall and winter of that year power generated by the release of that stored water will be turning the wheels of industry or heating new homes. This will be small start and in 1971 the full extent of the treaty benefits will be realized. A significant reduction of

flood stage will be experienced and power generation will be increased as the 20.5 million acre-feet of treaty storage are released through the 1,200 feet of head on the Columbia River and converted to electrical energy by the turbines presently being studied.

EMERGENCY PLAN FOR PUMPING WATER FOR EVERGLADES NATIONAL PARK

by

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Everglades National Park, located at the southern tip of Florida, is the largest subtropical wilderness in North America. Established in 1947, it covers an area of some 2,100 squire miles of land and water. It is primarily an aquatic area containing unusual plant and wildlife communities which abound in both fresh water and estuarine environments. Rainfall is the principal source of water needed to maintain the park ecology; however, an important additional supply is from overland flow across Tamiami Trail. Before the advent of manmade works, drainage in the area was generally southward from Lake Okeechobee and the vast Everglades marsh area north of the park. Alteration of the basic drainage pattern was occasioned by works of local interests between 1881 and 1927. Canals constructed by local landowners diverted much of the water that formerly drained slowly southward to and across the park, eastward to the ocean. During prolonged drought periods water levels in the park area were lowered below ground level affecting plant and animal ecology.

In 1948 the Congress authorized construction and operation of the Central and Southern flood control project. Included among the project works was the construction of three large water-conservation areas for storage and release of water for various purposes. One of the purposes recognized in the project document (H. Doc. 643, 80th Cong., 2d sess.) was that "the plan of improvement has also been developed in full recognition of the importance of the Everglades National Park***. Releases of water from conservation storage will assist in restoring and maintaining natural conditions within the national park area, by reducing damage from drought and fire which have threatened the pres-

ervation of lands, vegetation, and wildlife." The largest of the three conservation storage areas, noted above, is Conservation Area No. 3 located directly north of the park. Encirclement of that area by levees for water storage and construction of discharge facilities permitting releases to the park were not completed until 1962. Like the park, the conservation areas are also dependent on direct rainfall for their principal source of supply. Gravity discharges from Lake Okeechobee into the conservation areas are not very efficient because of the negligible gradient in existing canals and the resulting accumulation during discharge of water in the dense sawgrass surrounding the outlet works. Also evapotranspiration losses of water placed in storage in the conservation areas are extremely high.

In the last 3 or 4 years rainfall over the project area has been below normal. This has compounded the problem of accumulating water in Conservation Area No. 3 to levels that would require flood control release to the park. For example, during many of the months in the last several years' drought, water levels in the park on the south side of Tamiami Trail were higher than to the north in Conservation Area No. 3 Some accumulation of storage in 1964 permitted releases to be made to the park in accordance with a water-release schedule established by the Central and Southern Florida Flood Control District on the basis that the control of such water was vested in the State, except for flood control releases which are under the control of the Corps of Engineers. However, in view of the relatively small difference in water levels across the Tamiami Trail, and the lack of adequate conveyance in the dense park vegetation south of the project discharge structures, those discharges were consequently only nominal in terms of the minimum release requirements desired by the park officials.

In the past several years, the Corps of Engineers, National Park Service, and the Central and Southern Florida Flood Control District have been coordinating on various studies to determine ways and means of improving the water supply for this park. Those studies havei nvolved works within Conservation Area No. 3, such as reduction in seepage losses from that area by construction of parallel interior levees (L–67A and C) ; improvement of flow capacity and conveyance by plans for enlargement and extension of the North New River Canal and Miami Canal downstream from the agricultural area together with enlargement of levee 67A borrow canal to the discharge structures (S–12A through D) in Conservation Area No. 3. This enlargement work can be done

under existing authority with State participation and is planned for construction in the near future. Plans are also underway to initiate construction of a levee and canal (levee 67 extension) along the eastern boundary of the park to distribute water to the park more efficiently than under present capabilities.

The canal enlargement work noted above is an essential part of an interim plan recently developed and mutually agreed upon by the principal Federal and State agencies involved to transfer water from Lake Okeechobee to the park. Under that plan, initiated on March 5, 1966, water is being transferred to the park by gravity releases from the lake at predetermined rates depending on lake stage. Those releases are pumped to the conservation areas by the Flood Control District for discharge to the park. The cost of pumping water released to the park under this plan is reimbursable by the Corps. Pumping can be done at any or all of the project pumping stations (S–5A, S–6, S–7, and S–8), located along the southern edge of the Everglades Agricultural Area, at the option of the Flood Control District when it does not interfere with the removal of excess rainfall from the agricultural area. Payment for pumping in predicated on releases made to the park at the structure 12 spillways. The rates of release to the park were esentially related to the Lake Okeechobee regulation schedule. When the lake stage is within certain zones, release to the park at rates of 1,000 500, or 140 cubic feet per second are to be made. Certain exceptions apply to the above interim plan. When stages in the three conservation areas are all above the respective schedule for each area, no pumping is required. The same exception applies when flood discharges are necessary from Conservation Area No. 3 to the park. Lastly, when the park has received discharges from Conservation Area No. 3, accumulating 500,000 acre-feet in any given year, no further pumping of lake releases will be required.

The purpose of this interim plan is threefold—to provide an interim water supply for Everglades National Park until such time as alternative measures resulting from completion of the survey report on Everglades National Park Water Supply, now being prepared, can be effected; to reduce the amount of excess water discharged to tidewater from Lake Okeechobee via the Caloosahatchee River and St. Lucie Canal when necessary to safeguard life and property, thereby conserving water; and, lastly, to improve and make more efficient use of the Central and Southern Florida Flood Control Project facilities for the benefit of all

users and project purposes. Expenditure of Federal funds for this plan and its basic purpose is now authorized by use of maintenance and operation funds of the project. It is estimated that these cost will amount to from $75,000 to $150,000 per year.

This interim plan is not intended to resolve the water supply problems of Everglades National Park. It does represent a practical approach to the problem and a cooperative effort on the part of the Corps of Engineers and the State of Florida to assist the park in this regard.

THE FOURTH SEACOAST[1]

by

Major James M. Neil

U.S. Army

Within the boundary of the states of the United States and the provinces of Canada which adjoin the Great Lakes is an area with a population of 55,000,000. It is the source of almost 80 percent of the steel, 40 percent of the agricultural produce and the greater part of the equipment and products of heavy industry made in the United States and Canada. Much of the growth and potential of this region is based upon the vast waterways of the Great Lakes which, until 1959, had no link to the ocean for the passage of deep-draft vessels. When the St. Lawrence Seaway was officially opened on June 26, 1959, making the Great Lakes accessible to such vessels for the first time, a Fourth Seacoast of the United States was created which added even more potential to these heartland areas of this country and Canada.

Significant as the Seaway is, it is by no means the only major work of man required to make the Fourth Seacoast a reality. It is but one of a number of constructions projects which have made possible deepdraft navigation throughout the Great Lakes System. Nor will this system ever be complete. Ship owners will continue to redesign and enlarge their vessels to hold their position in the highly competitive transportation market. Raw material sources, markets, and industries will change and expand, and navigation facilities will have to keep pace.

HISTORY OF DEVELOPMENT

As shown on the map (Figure 1), only two of the major lakes,

Figure 1. The Great Lakes Waterway

The Military Engineer

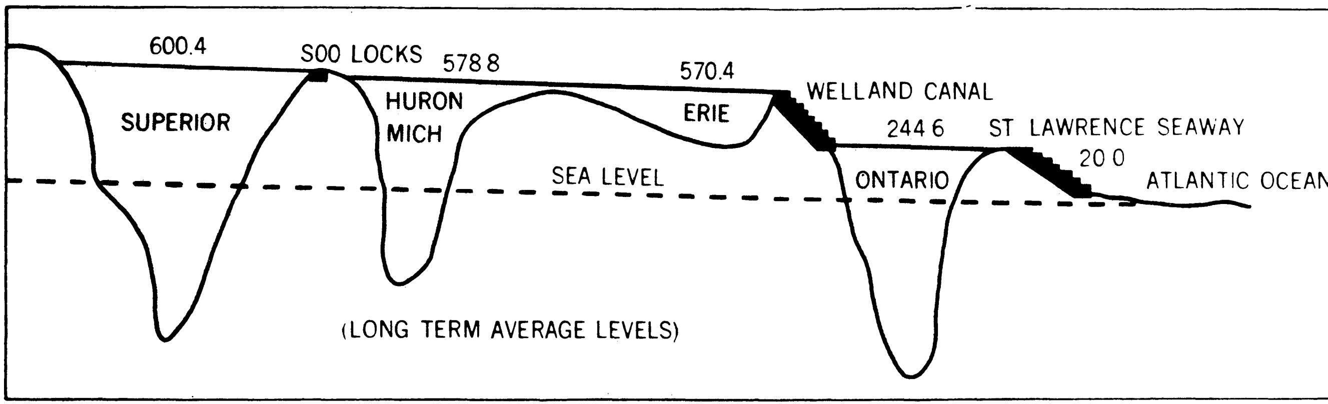

Figure 2 Profile of the Great Lakes and St. Lawrence Seaway

The Military Engineer

Huron and Michigan, are joined by open water—the Straits of Mackinac. All others are connected by rivers or rivers in combination with smaller lakes. Rivers usually have rapids, shoals, and other channel restrictions which in their natural state obstruct navigation for large vessels. The rivers connecting the Great Lakes are no exception. Other obstacles shown in profile (Figure 2) are the differences in elevation between certain lakes. Between Lakes Superior and Huron the difference in elevation is 22 feet. Lakes Michigan and Huron are of the same level, while Lakes Huron and Erie differ by only a few feet. Between Lakes Erie and Ontario the Niagara escarpment creates a drop of 326 feet. Finally, between Lake Ontario and the Atlantic Ocean the difference is 245 feet.

Throughout the history of the United States and Canada man has sought means to overcome these obstacles. In the earliest years the only method was portage, but in the past 175 years the construction of canal and lock systems and the deepening of existing channels have solved the problems. Each of the obstructed areas in the Great Lakes-Seaway System has its own history of such efforts.

LAKE SUPERIOR TO HURON–MICHIGAN

Lakes Superior and Huron-Michigan are connected by the St. Mary's River and several small lakes which form a circuitous 65-mile water route that in its natural state is impassible to navigation because of the St. Mary's Rapids near Sault Ste. Marie, Michigan. The first lock to bypass these rapids was built by the Northwest Fur Company in 1797. This lock was destroyed by American troops during the war of 1812 and was not replaced until 1855 when the State of Michigan constructed two locks in tandem. In 1896 they were replaced by the Poe Lock. In 1881 the parallel Weitzel Lock was completed by the United States and was used until 1943 when it was replaced by the MacArthur Lock. In 1895 the Canadians built a parallel lock which is still used. The Davis and Sabin Locks were built by the United States in 1914 and 1919, respectively, adjacent to the other American locks. Within the past three years the Poe Lock has been demolished and a new lock 110 feet wide, 1,200 feet long, and 32 feet deep, is under construction. When complete in 1967, this lock will be the largest in the Great Lakes System. It is significant that traffic through these "Soo" Locks exceeds that of any other canal

system in the world.[2]

To make the St. Mary's River navigable for large vessels, channel improvements in addition to the locks were required, including deepening, widening, improving alignment, and removing shoals along most of the 65-mile route. The most recent improvements were dredging to the Seaway depths between 1957 and 1964. In the Straits of Mackinac, between Lakes Huron and Michigan, only two relatively small shoal areas had to be removed to bring this reach up to Seaway standards.

LAKE HURON TO LAKE ERIE

From Lake Huron to Lake Erie, the St. Clair River, Lake St. Clair, and the Detroit River provide the water connection. This waterway, almost 100 miles long, contains no obstructing rapids or falls but channel improvements along most of its length were required to provide a depth of 27 feet for vessels of maximum Seaway dimensions.

LAKE ERIE TO LAKE ONTARIO

The Niagara River and Niagara Falls originally passed all water from Lake Erie to Lake Ontario. The drop between these lakes provided a major obstacle to water commerce until 1829 when the Canadians completed their first navigable crossing. This waterway used part of the Niagara River and the Welland River, thence across country by canal and through locks to Twelve Mile Creek and into Lake Ontario at Port Dalhousie. In 1833 the river portions of the route were eliminated by the construction of an 11-mile canal making a direct connection to Lake Erie at Port Colborne. The completed waterway (the First Welland Canal) was built by the Welland Canal Company. It was 27½ miles long and contained forty wooden locks. Within a few years, the maintenance of the wooden locks became such a burden that the company appealed to the Government of Upper Canada for assistance. The Government bought out the company in 1841 and began an improvement program, replacing the wooden locks with twenty-seven masonary structures, 150 by 26½ feet with a depth of 9 feet. Other features of this waterway (the Second Welland Canal) remained essentially the same as before.

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[2] The American locks are operated by the Detroit District, Army Corps of Engineers, and are toll free.

The growth of waterborne commerce, spurred by the development of steam power, soon demanded larger locks and greater depth for the canal. Another improvement program was launched, and by 1887 the Third Welland Canal, containing twenty-six cutstone locks, 270 by 45 feet and 14 feet deep, had been built and the canal channels improved.

It was about this time that the typical lake-type carrier appeared. This steam-powered vessel was essentially a self-propelled barge with the bridge at the forward end and machinery aft. The canal was not large enough for these new "lakers" to navigate between Lakes Erie and Ontario, it was inevitable that plans should be made to enlarge the Welland Canal for these vessels; hence, the Fourth Welland Canal was completed in 1932, with seven lift locks, three of them twinned, and one guard lock, all at least 859 by 80 feet and 30 feet deep. Canal channel alignments were changed to provide a more direct north-south crossing between Port Colborne and Port Weller. These huge locks take vessels as large as those of the Seaway and can accommodate the largest lake vessels, although the new 730-foot bulk cargo carriers must pass with great caution.

Following the 1964 navigation season the Canadian Saint Lawrence Seaway Authority, which operates the Welland Canal as well as the Canadian portion of the Seaway, began a six-year program aimed at twinning all remaining single locks and modernizing other facilities to increase the capacity of the Canal. Twinning the locks is expected to increase the capacity by 60 percent and thus relieve much of the congestion that now prevails during the height of the navigation season.

LAKE ONTARIO TO THE ATLANTIC

The St. Lawrence River originates at the east end of Lake Ontario and passes through the Thousand Islands and the International Rapids section for a distance of 115 miles to the head of Lake St. Francis, about 6 miles below Messena, New York. Past Lake St. Francis the channel follows a rapids section and then enters Lake St. Louis just above Montreal. Montreal, at an elevation of 20 feet above sea level, lies 223 feet below and 185 water miles away from Lake Ontario. A navigable channel along this tortuous waterway was first created in the 1840's when canals were dug and twenty-eight locks were constructed to bypass the many steep reaches. These canals and locks were built to the

same specifications as the Second Welland Canal with depths to 9 feet. Late in the 19th Century, the canals and locks were deepened to 14 feet and the number of locks reduced to twenty-two. This last system was still in use at the time construction of the present St. Lawrence Seaway was begun in 1955.

Much of the original canal and lock system along the St. Lawrence is now under water as a result of Seaway construction. The Long Sault and Moses-Saunders dams in the vicinity of Messena, New York, raised the elevation of the St. Lawrence River by about 90 feet and created the body of water known as Lake St. Lawrence. The Seaway project also included seven navigation locks and many miles of channel excavation. Five of the locks were built and are operated by Canada while two are American (Eisenhower and Snell). All locks are 860 by 80 feet and 30 feet deep.

LAKES-SEAWAY TRAFFIC

All canals, locks, and connecting channel improvements will accommodate safe passage of a vessel 730 by 75 feet with 25½ feet of draft. Accordingly, these dimensions are the limits for vessels seeking access to all the Lakes or to the Atlantic Ocean. Larger vessels could be used on routes involving only ports west of the Welland Canal. The new lock at Sault Ste. Marie will be able to pass vessels 100 by 900 feet between Lakes Superior and Huron-Michigan. Even larger vessels could now pass between Lakes Erie and Huron and between Lakes Huron and Michigan.

Thus far the American and Canadian shipbuilders do not have any lake ships larger than the present limits but 900- and 1,000-foot vessels are being proposed and will eventually be plying the lakes. The first 700-foot laker made its appearance twelve years ago, and in 1964 only one of eight lakers under construction was less than 700 feet. Bulk cargo carriers under 500 feet are of marginal economy and vessels in the 600- and 700-foot classes dominate the bulk cargo routes. For economic reasons, many smaller vessels are being lengthened and repowered or being scrapped.

The serious obstacles to deep-draft navigation are the harbors along the Great Lakes. Prior to the completion of the St. Lawrence Seaway, no inner harbors were maintained to a depth of over 25 feet. This was adequate for a vessel draft of only 23½ feet. When the Seaway was built to take vessels with 25½-foot draft, this

limitation of harbors was recognized, and a series of individual harbor studies was made.[3] As a result, harbors in all lakes have been deepened and improved. Theer are now more than twenty private and public harbors maintained to depths of at least 27 feet. Other harbors with depths from 18–26 feet have been improved where economically justified by new trade and traffic patterns.

THE FUTURE

Future navigation improvements in the Great Lakes System will be made as the traffic demands. The participation of the Canadian and United States Governments in such improvements will depend largely on the economic effect as well as on military and political considerations.

Through the Soo Locks, annual cargo tonnage has ranged from 72,000,000 to 114,000,000 tons over the past ten years, with the peak occurring in 1955–1957. Existing facilities and those under construction at these locks will be adequate without further expansion for some time. The opening of the Seaway had little effect on the amount of traffic through the Soo Locks; export-import tonnage runs less than 5 percent of the total at this point.

On the other hand, traffic on the Welland Canal has risen sharply since completion of the Seaway. (See Figure 3). The

[3] By Districts of the North Central Division, Army Corps of Engineers.

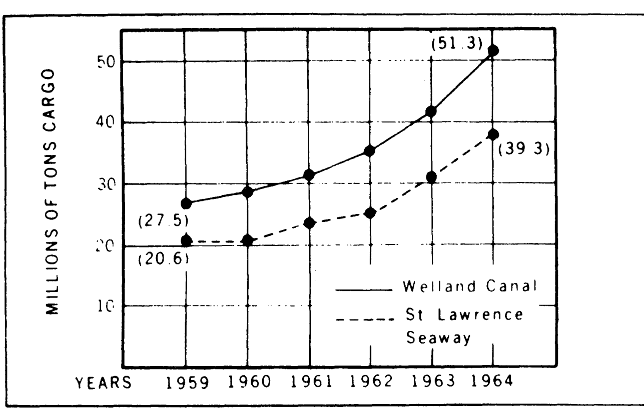

Figure 3. Growth of Traffic

The Military Engineer

canal has reached its capacity but the twinning program is expected to provide relief for another ten to fifteen years. Beyond that, if traffic continues to increase, a larger canal will be needed. In anticipation of this, American interests are urging the construction of a new waterway between Lakes Erie and Ontario in the United States, and Congress has appropriated some funds for a survey of such a project. Typical routes being studied are shown in Figure 4. All propose to follow the Niagara River from the north entrance of Buffalo Harbor to North Tonawanda, New York. From there, the canal would cut across the Niagara escarpment to Lake Ontario following whatever alignment is found to be the most economical and feasible. This waterway and its locks probably would be built to accommodate 900- and 1,000-foot vessels.

The St. Lawrence Seaway did not have the expected traffic during its early years of operation but in 1963 and 1964 traffic increased and is now about 60 percent of the practical limit of the locks.

The mighty construction feats which made the Fourth Seacoast possible will some day be dim memories as newer, bolder plans are developed to provide more extensive, more convenient, and more efficient water routes which include the Great Lakes.

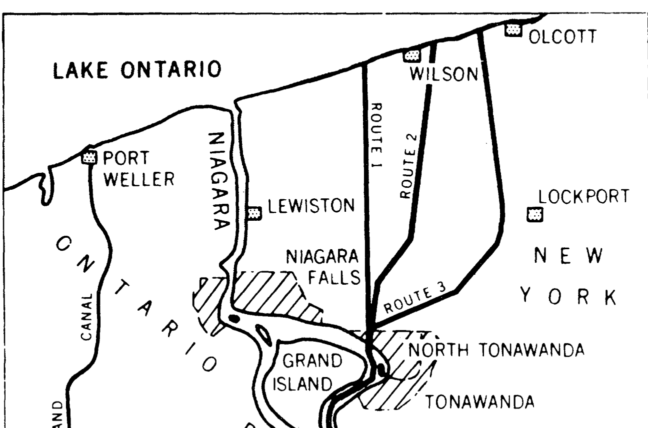

Figure 4. Possible Routes of Lake Erie-Lake Ontario Waterway

The Military Engineer

INTEGRATED OPERATION OF MISSOURI RIVER RESERVOIRS FOR MULTIPLE–PURPOSE USE

by

T. Waara

Hydraulic Engineer, Engineering Division, U.S. Army Engineer Division, Missouri River

SYNOPSIS

The watershed of the Missouri River, constituting more than one-seventh of the landmass of the 48 continguous United States, offered for many decades a challenging example of wasteful and often ravaging neglect of water resources. These resources are now being regulated and put to constructive use by six Missouri River dams with a gross storage in excess of 75 million acre-feet. Compared to a mean flow past the lowermost dam of almost 24 million acre-feet per year, this high ratio of storage to flow has provided much operational flexibility in regulating the system.

The fact that choices were possible led to sharp differences of opinion during early days of system operation concerning appropriate objectives. These differences, which were accentuated by a severe drought during the initial-fill period, centered around whether navigation or power generation should receive preferential treatment.

To provide a means of recognizing and deliberating these differing views the Corps of Engineers established the Coordinating Committee on Missouri River Main Stem Reservoir Operations. Governor-appointed representatives of the 10 basin States together with spokesmen for seven Federal agencies in addition to the Corps of Engineers meet at least twice a year to arrive at desirable objectives for operation of the system. The Committee deserves much credit for its success in resolving conflicts of opinion and developing unified operating plans.

Operating techniques have also contributed significantly to the solution of early differences between power and navigation in-

terests. A procedure for balancing system generation by holding back upstream releases when downstream flows are high and vice versa has been put into effect. This makes possible a reconciliation of navigation's need for high summer flows with the power market's need for maximum generation during the winter period.

INTRODUCTION

There is a fascination about a great dam and reservoir project which stirs even those members of the public most remote from the fields of engineering, construction of water resources management. The coverage given in newspapers, magazines, and other news media to the progress of construction and the delivery of present or future benefits of various kinds at the site of a large multiple-purpose dam is continuing evidence of this general interest. Although such a project may soon become a familiar adjunct to the affairs of a quite extensive community, its full capabilities—and its full responsibilities and restrictions—are not widely understood.

One reason for this perhaps, is that in spite of the publicity they have received in recent years, multiple-purpose projects still comprise a distinct minority of the total reservoirs operating in the United States. The "Register of Dams in the United States" lists over 2,600 as completed and in service at the end of 1962. Of these, only 22 percent were classified as multiple-purpose, even with recreation considered as one of the categories of service. The trend toward more such multiple-use projects is evident in the Register's compilation of dams still under construction in 1962—many of which are now completed and in service. Of 217 dams listed, 48 percent were designed for multiple-purpose operation and of the 94 with a gross capacity of 100,000 acre-feet or more, 77 percent were in the multiple-purpose classification. It seems evident that future users of our national water resources in any of their numerous aspects will be increasingly exposed to the always complex, often puzzling, and occasionally exasperating influence of multiple-purpose reservoir operations.

The ultimate prevalence of this trend has been apparent to far-sighted water engineers for several decades. In the "Transactions of the American Society of Civil Engineers for 1935,"[1] Gerard H.

[1] Mattes, G., "Discussion on Reservoirs for Flood Control," Trans. of A.S.C.E., 1935, v. 100 p. 920.

Matthes wrote: "The conclusion is inescapable that the multiple-use reservoir is destined to play an increasingly important role in the future... Many of those who have written about the incompatibility of operating a reservoir, or system of reservoirs, for joint power development and flood control have overlooked the fact that this incompatibility resides not so much in the physical aspects of operation as in the divergency of interests which exist between corporate use and public conservation of water... Even in the most advantageous physical setups, absolute agreement between the interests sharing the storage space in a reservoir is essential. This agreement should amount to a unity of purpose and should take the form of unified control, if the best results are to be obtained because, in any combination, one usage may be called upon, at times, to sacrifice to the other."

These prescient remarks are to a remarkable extent a summation of the experience acquired during the operation of the Missouri River Main Stem Reservoir System. The unity of purpose which Mr. Matthes recognized as so essential has been achieved by a means he could not foresee, an almost unique application of diverse interests to a common cause which will be discussed later in some detail. And though his principles were phrased to include their application to a system of reservoirs as well as to a single multiple-purpose structure, Mr. Matthes might have been hard pressed to anticipate the regulation of a watershed as completely as that task is accomplished on the Missouri River main stem today.

One measure of the degree of regulation is the ratio of reservoir storage to annual runoff. In the Columbia and Ohio River Basins this ratio is 1:5; approximately 1 acre-foot of storage for each 5 acre-feet of annual runoff. In the Missouri River Basin, the ratio is 1.6:1. This ratio, computed at the river's mouth, is exceeded on the Colorado River which has a ratio of 2.1:1. Regulation by the Missouri River Main Stem Reservoirs is confined to the northern half of the basin, some 280,000 square miles lying above Sioux City, Iowa. The ratio provided in this drainage area is 3.1 acre-feet of storage for each acre-foot of natural runoff.

It is this high ratio of storage to runoff, combined with the technique of operating the six main stem dams as an entity, which provides the flexibility and sustained delivery of service characteristic of this system. Here the whole is greater than the sum of its parts; no one of our multiple-purpose projects in isolated operation could accomplish its proportion of the results

which have been achieved through integrated operation of a responsive series of reservoirs.

DESCRIPTION OF THE SYSTEM

The watershed of the Missouri Basin spreads across more than half a million square miles, encompassing all of one State, portions of nine more and extending at its northern limit across the international boundary into Alberta and Saskatechewan. The river's mouth, just above St. Louis, is closer to New Orleans and to the Atlantic seaboard than to its own headwaters at the confluence of the Gallatin, Madison, and Jefferson 2,300 river miles to the northwest. This is a region of extremes; from an elevation of 380 feet above sea level at the mouth the land rises seven-tenths of a mile to the headwaters elevation of 4,050 feet above sea level; tributaries draining the eastern slope of the Continental Divide have catchment areas rising to 14,000 feet above the sea. Precipitation also varies widely, from an annual mean of 40 inches in the southeast to a scant 10 inches in areas of the dry upland plains, rising again to 40 inches in the mountains. As one would expect in a basin of this size, precipitation during any given year will deviate widely from the mean in many subareas.

The behavior of the unregulated Missouri River was a function of this congeries of extremes. Calendar year natural runoff above Sioux City, the water supply analyzed for the design and operation of the main stem projects, has fluctuated from a low of 10,700,000 acre-feet in 1931 to a high of 37 million acre-feet in 1927. Natural runoff for a one-month period has ranged from 37,000 acre-feet in December of 1961 to 12,900,000 acre-feet in April of 1952. The consequences implicit in such a record, as they affected development of the flood plain, water suply and stream sanitation, reliable navigation schedules and irrigation diversions, need no elaboration.

Despite this pattern of excesses and deficiencies the river's underlying potential yield of benefits was evident. For the long term, mean natural flow exceeded 24 million acre-feet a year at Sioux City with a differential head of 1,080 feet between the points which would ultimately situate Gavins Point Dam and the top of pool at Fort Peck. Given adequate regulation, here was a water supply sufficient to satisfy and even stimulate consumptive use in the upper basin, to provide a stabilized base flow for

navigation and for municipal supply in the lower basin, and to geenrate large blocks of electrical energy en route.

The first step toward harnessing this potential was the construction of Fort Peck Dam. Early authorizing legislation contemplated its use for "improving navigation on the Missouri River and for other purposes incidental thereto." Closure was made in 1937; during the next 15 years it operated alone to support navigation, regulate upper basin floods, and generate power. Extensive plans for further control of the river were developed in this interim by several Federal agencies. Two of the most comprehensive were the proposal of the Corps of Engineers, oriented toward flood control and navigation and that of the Bureau of Reclamation, emphasizing irrigation and hydroelectric power generation. Known respectively as the Pick Plan after the Chief of the Corps Missouri River Division and the Sloan Plan for the Assistant Regional Director of the U.S.B.R.'s Region 6, the two programs were consolidated during joint meetings in October 1944 and their major features incorporated by the Flood Control Act of 1944, enacted in December of that same year.

More than 100 reservoirs throughout the Missouri Basin were authorized by this act, but its cardinal feature was the integrated multiple-purpose operation of the six main stem dams. Big Bend, the last of these projects to be constructed, began generation of commercial power on October 2, 1964. Except for the addition of generating units at Big Bend which will continue through mid-1966, the Corps of Engineers has essentially completed construction of these projects. Some of their salient characteristics are listed in table I; their geographical relationship is shown by the map in figure 1.

THE MEANS OF SYSTEM OPERATIONS

Fort Randall, first of the main stem projects to be constructed under provisions of the 1944 Flood Control Act, was closed in 1952, and by the following year was effectively augmenting the burden of regulation previously carried by Fort Peck alone. Garrison, Gavins Point, and Oahe closures followed in 1953, 1955, and 1958. Thus, within a 6-year span was imposed the requirement to fill 12,200,000 acre-feet of newly created inactive storage space alone, in addition to accumulating storage reserves in 30 million acre-feet of available conservation storage capacity.

Table I. Physical Data—Missouri River Main Stem Reservoirs

Project	*Volume of earth fill in dam (cubic yeards)*	*Storage in acre-feet*			*Installed capacity in kilowatts*
		Gross	*Inactive*	*Annual and exclusive flood control*	
Fort Peck	125,600,000	19,100,000	4,300,000	3,700,000	165,000
Garrison	66,500,000	24,400,000	5,000,000	5,800,000	400,000
Oahe	92,000,000	23,600,000	5,500,000	4,300,000	595,000
Big Bend	17,000,000	1,900,000	1,465,000	175,000	468,000
Fort Randall	50,000,000	5,800,000	1,300,000	2,300,000	320,000
Gavins Point	7,000,000	540,000	155,000	165,000	100,000
System total	358,100,000	75,340,000	17,720,000	16,440,000	2,048,000

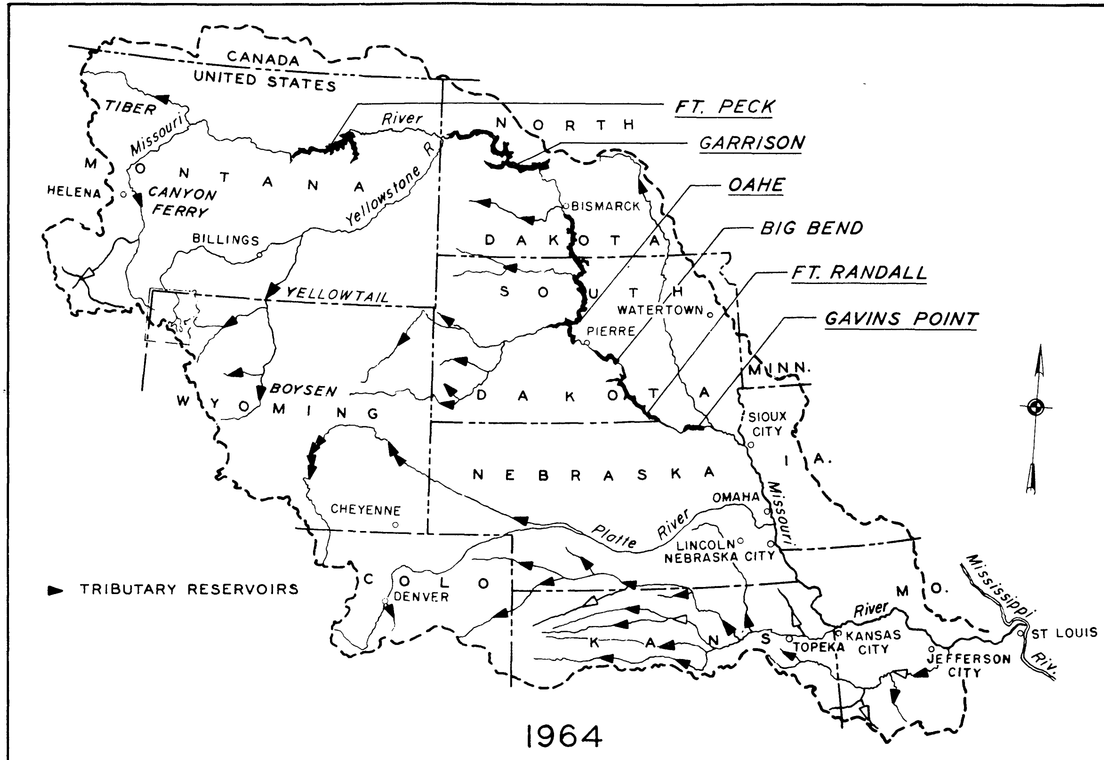
CANADA
UNITED STATES
FT. PECK
GARRISON
OAHE
BIG BEND
FT. RANDALL
GAVINS POINT
TIBER
Missouri
River
M O N T A N A
HELENA
CANYON FERRY
BILLINGS
Yellowstone R.
YELLOWTAIL
BOYSEN
W Y O M I N G
CHEYENNE
N O R T H
D A K O T A
BISMARCK
S O U T H
D A K O T A
WATERTOWN
PIERRE
MINN.
SIOUX CITY
I A.
N E B R A S K A
OMAHA
Missouri
Platte River
LINCOLN
NEBRASKA CITY
C O L O
DENVER
K A N S
TOPEKA
KANSAS CITY
River
M O.
JEFFERSON CITY
Mississippi Riv.
ST LOUIS
TRIBUTARY RESERVOIRS
1964

Figure 1

ANNUAL WATER SUPPLY
MISSOURI RIVER AT SIOUX CITY

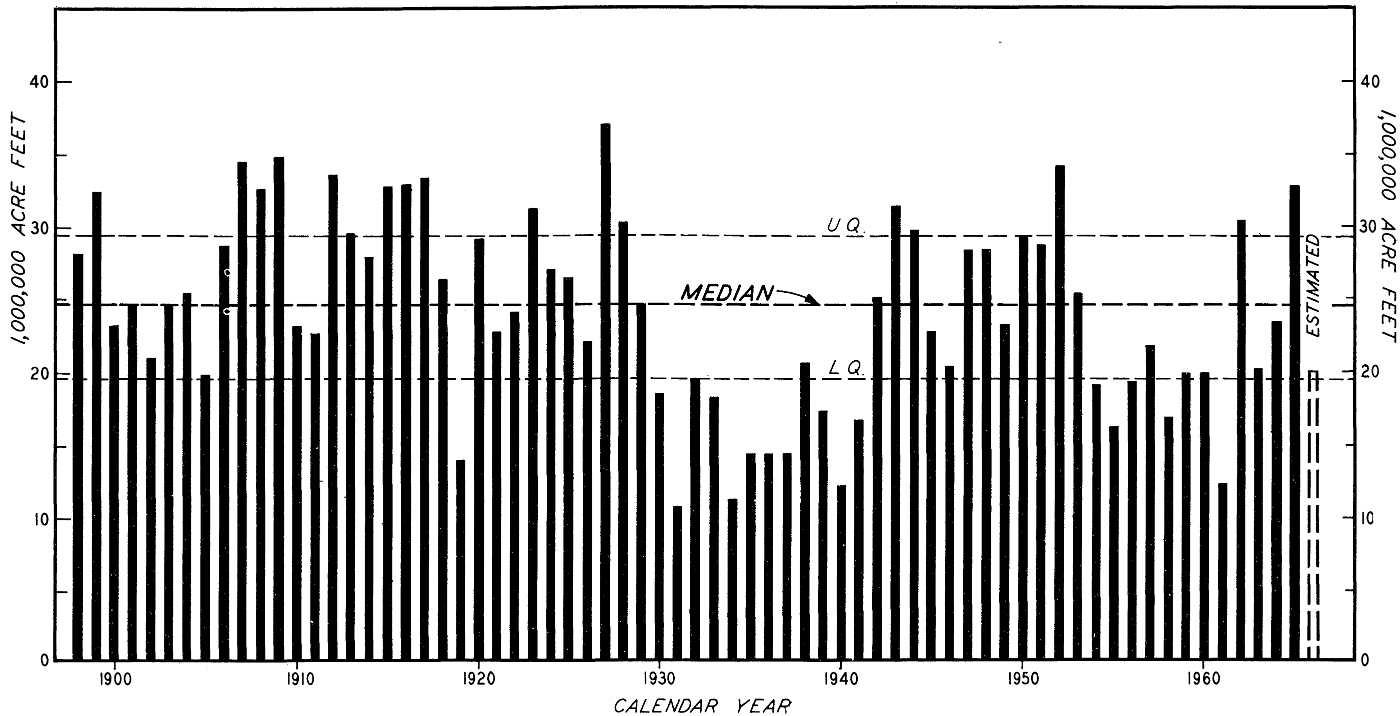

Figure 2

Under median conditions of water supply the accomplishment of this initial fill would have presented no problem; indeed any inflow greater than lower quartile in range, if sustained throughout this period would have made possible steady progress in performing the task. The water yield which did ensue is indicated by the bar chart in figure 2.

Flow data on the Missouri River has been reconstructed back to the year 1898. Throughout the course of this record the great drought of the 1930's is conspicuous for its protracted sequence of markedly subnormal inflows. Compared to a median annual natural water supply of 24.6 million acre-feet, the average annual volume for the years 1930 through 1941 amounted to only 15.6 million acre-feet and included 3 years with less runoff than the single month of April 1952 which has been cited earlier. Accurate statistical evaluation of the recurrence interval of so rare an event from a relatively short period of record is difficult but probably lies between several hundred and several thousand years.

This drought had been recognized in the design of the main stem system and in fact was utilized in establishing the period of critical drawdown. In view of the large ratio of storage to annual water supply in the main stem projects, the usual procedure of fixing the critical condition on the basis of a repetition of the worst single year or even worst 2-year sequence of record would be an inadequate measure of criticality. On the other hand, utilization of the full drought period, which was highly unlikely to recur during the projected economic life of the system as the criterion for firm power, was felt to be undue conservatism. The selection finally decided upon was the end of the fourth year of the drought, on the premise that such a period would provide time for the acquisition of alternative sources of electric power, after which a gradual curtailment of service to both power and navigation, but not irrigation, would proceed through the remainder of the 12-year drought period.

Then in 1954, coincident with the need for sizeable impoundments in Fort Randall and Garrison, there began a drought second in duration and in deficiency of flow only to the drought of 1930. Natural inflow during the period 1954 through 1961 averaged 17.8 million acre-feet a year, 2.2 million acre-feet above the average for the record drought but still 1.7 million acre-feet per year below the lower quartile volume. The sequence was broken with upper quartile yield in 1962 and 1965 and a median volume yield in 1964.

The growing pains normally attendant upon the early days of any undertaking as large as the Missouri main stem system were thus compounded many fold. The obvious lack of sufficient water to meet the demands of every interest during this period resulted in sharply divergent views upon how the available supply should best be administered; their focal point was the conflict between proponents of power generation and of navigation.

The marketing area for Missouri Basin power experiences its peak load during the winter months, usually in December. Since ability to fulfill contracts for firm power rests upon ability to meet peak loads, it was desirable from the standpoint of power production to operate the main stem projects in such a way as to hold winter generation at a relatively high level in reference to sumer loads. Any sizeable summer excess had to be marketed as dump power at a considerably lower price. And since the output of a hydroplant increases with increasing head, power interests placed a premium upon early and rapid storage gain.

Navigation, on the other hand, required the maintenance of adequate channel depths during the open water season; cutting winter flows to minimum sanitation levels was a means its proponents suggested to conserve the water supply during those lean years. Here assuredly was an urgent and knotty requirement to provide the unity of purpose needed in administering the young system.

Legal responsibility for operation of the main stem reservoirs within the scope of the enacting legislation had been delegated by Congress to the Chief of Engineers and to his representative, the Division Engineer of the Missouri River Division. This responsibility could not, of course, be further delegated. But within these legislated responsibilities lay considerable areas of choice, the exercise of which might reconcile or further estrange divisive interest.

The Corps of Engineers determined to provide a forum at which a representative from each of the basin States could speak for all of the interests in his area and representatives of the Federal agencies concerned with water resources management could give advice and recommendations concerning their fields of activity. In 1953 the Missouri River Division Engineer invited each of the 10 basin State governors to appoint his chief water resources engineer to membership on the Coordinating Committee on Missouri River Main Stem Reservoir Operations. Spokesmen for eight Federal agencies completed the membership; the Chief

of the Reservoir Control Center of the Missouri River Division, Corps of Engineers was designated as permanent chairman. A diagram of this organization is shown in figure 3.

Since it was first convened the Coordinating Committee has met twice each year at regularly scheduled spring and fall sessions, with additional special meetings having been called on several occasions. The calibre of this bodly, assembled from state engineers widely known and respected by their own constituents, has made its deliberations very effective. Although each member vigorously presents the needs and interests of his own region, the engineering experiences and maturity of judgment of these representatives have produced a remarkable degree of appreciation for the problems causing concern to other areas of the basin and a sincere desire to obtain the maximum in overall benefits from integrated operation of the main stem system. The effectiveness of their work may be measured in part by the fact that their annual recommendations have been accepted every year by the Missouri River Division Engineer as the basis for the following year's operation plan. A further measure lies in the conviction they have been able to implant at each local level that it is being well represented in the making of operational decisions. This conviction may be credited with averting a bitter political struggle to allocate water usage by legislation during the dry early years of the system.

COORDINATION OF MISSOURI RIVER
RESERVOIR OPERATIONS

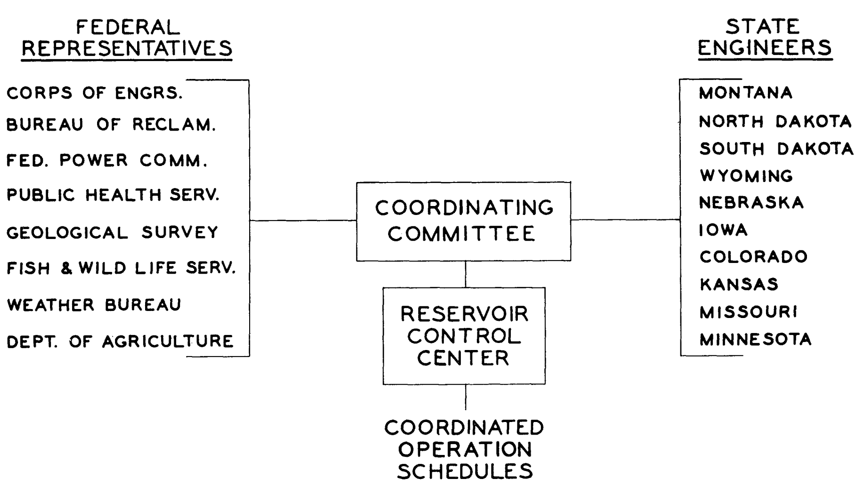

Figure 3

Many compromises were necessary in the retention of this unity of purpose. Contracts for the marketing of system energy generation were negotiated somewhat more slowly than early schedules had planned. Navigation season lengths were curtailed from the full open-water period of 8 months—by as much as 2 months on one occasion. Total system storage grew by painfully small increments, with losses during especially poor water years at times wiping out the prior year's gain. But storage did grow, commerce on the river did increase, power generation did expand steadily as new units were added and power heads gained additional feet. And for this realization of benefits, in the interest of which it had called upon not one, but all water usages to sacrifice in the common good, the Coordinating Committee deserves much credit. Its successful functioning has been one of the keystones of integrated system operation.

Continuity in the accomplishment of this integrated operation is provided by two devices: a plan and an organization to implement it. The plan is published each August as a document of some 40 pages. Known as the "Missouri River Main Stem Reservoirs Annual Operating Plan," each issue reviews actual conditions of water supply and operation of the reservoirs during the past 12 months and projects these conditions through a forecast of the recession hydrograph for the remaining months of the current year. Since hydrologic forecasts a year in advance are beyond the state of the art, the succeeding calendar year is analyzed through the application of a range of conditions. By assuming the occurrence of an upper quartile, median, lower quartile and adverse water year, performance of the system is studied within a bracket of water supplies from 13 to 30 million acre-feet. Finally, a 5-year projection departing from these studies with a further succession of various water supplies gives a longer-range appraisal of the probable scope of system operation. It is to this plan that the Coordinating Committee extends its deliberations and recommendations upon such items as length of navigation season and target gain in system storage. Special considerations which are desirable from a local standpoint may be introduced and their compatibility with overall operation evaluated.

Guided by the advice and recommendations of the Coordinating Committee, the Corps of Engineers prepares the plan and distributes it. This is a public document of interest to many governmental agencies, businesses, and individuals who have some concern with the status of the reservoirs or of riverflows below them.

In final form it becomes a firm commitment upon the length of the current year's navigation season, enabling navigators and shippers to plan traffic schedules. Similarly, it constitutes an advance assurance of minimum monthly generation available, facilitating the marketing of firm power for the year. The plan also serves as the framework within which is accomplished the scheduling of detailed daily and weekly operation of the individual main stem reservoirs. This is the task of the implementing organization, the Reservoir Control Center.

Housed in the offices of the Missouri River Division, the Reservoir Control Center has a full-time staff of 12 persons. It is divided into two sections of about equal size: Reservoir Regulation and Power Production. These sections have the responsibility of analyzing and acting upon the many reports of precipitation, inflow, project elevations and releases, river stages and tow boat schedules which funnel into the Center 365 days a year. Working in close association with the Watertown, S. Dak., dispatching office of the Bureau of Reclamation—which is the power marketing agency for all Federal power generated in the upper basin—the staff of the Control Center translates daily Bureau estimates of required total load into specific targets of generation and release at each of the six main stem plants. Theirs, too, is the job of preparing initial drafts of the Annual Operating Plan and incorporating Coordinating Committee recommendations into the plan's final form after its approval by the Division Engineer. Detailed scheduling of flood operations is also handled in this office as the occasion arises; if necessary, its staff is augmented by other experienced hydrologists from the Division and Omaha and Kansas City District offices to conduct around-the-clock operations.

Considerable equipment is utilized in the process of these operations. A closed circuit teletype net connects the Center with each of the operating projects; the Division radio net provides backup communication. Other teletypes, tied to regional and local Weather Bureau lines are a continuous source of current data, while a facsimile printer transmits frequent weather maps from the National Meteorological Center at Suitland, Md. Another frequently used tool is the RCA 301 digital computer. With this machine it is possible in 5 minutes to analyze operations of the main stem projects through 12 months. Such studies form the basis for Annual Operating Plans and other investigations; before the computer was available each study required the time of an engineer for over a day.

TECHNIQUES OF INTEGRATED OPERATION

It may well be that excessive time has been devoted to a description of the physical characteristics of the basin and the background and historic development of the existing regimen. The writer found himself trapped, however, by the dilemma of verbosity or unintelligibility. Billion dollar systems such as that on the Missouri River main stem are not turned out on assembly lines. Each is a painstakingly tailored creature of its environment; each has its own set of performance characteristics. Without some prior delineation of these characteristics, any discussion of specific operations is apt to prove meaningless.

No system, moreover, is built or run in a vacuum. While each is physically unique, all have in common the factor that they are conceived by, and bought by, and used by people. And although human nature in the particulate may vary as widely as the climate of the Missouri Basin, in the aggregate it is rather a uniform commodity of the world around. For this reason it was felt that the methods developed in this system for liaison and the exchange of ideas and the arrival at understandings might be of more than local application and interest.

Turning now to current techniques of integrated system operation, one finds a marked change from the condtions during the early period of initial fill. The recent years of favorable water supply have accomplished fill of the conservation storage in the system to its interim level. All six projects are in essentially full service. The full flexibility of a completed system with adequate storage reserves is now at hand.

This flexibility has provided a solution to the early conflict between the requirements of service to power and service to navigation. It will be recalled that navigation needs summer flows of two or three times the magnitude necessary for minimum water supply and stream sanitation levels in this winter. The market for firm power, on the contrary, reaches a peak in the winter months and any summer generation greatly in excess of this level must be sold at reduced dump power rates. Resolution of this seeming incompatibility was accomplished by operating the system as two separate and complementary parts. The lower two reservoirs, Fort Randall and Gavins Point, follow a pattern of releases designed to serve navigation. Figure 4 shows the effect of this regulation during 1961 and 1962 at Sioux City, Iowa—the head of the commercial navigation channel. The characteristic alternation of high summer and low winter flows is evident. Also indicated on figure 4 by the dashed plot is the natural flow Sioux

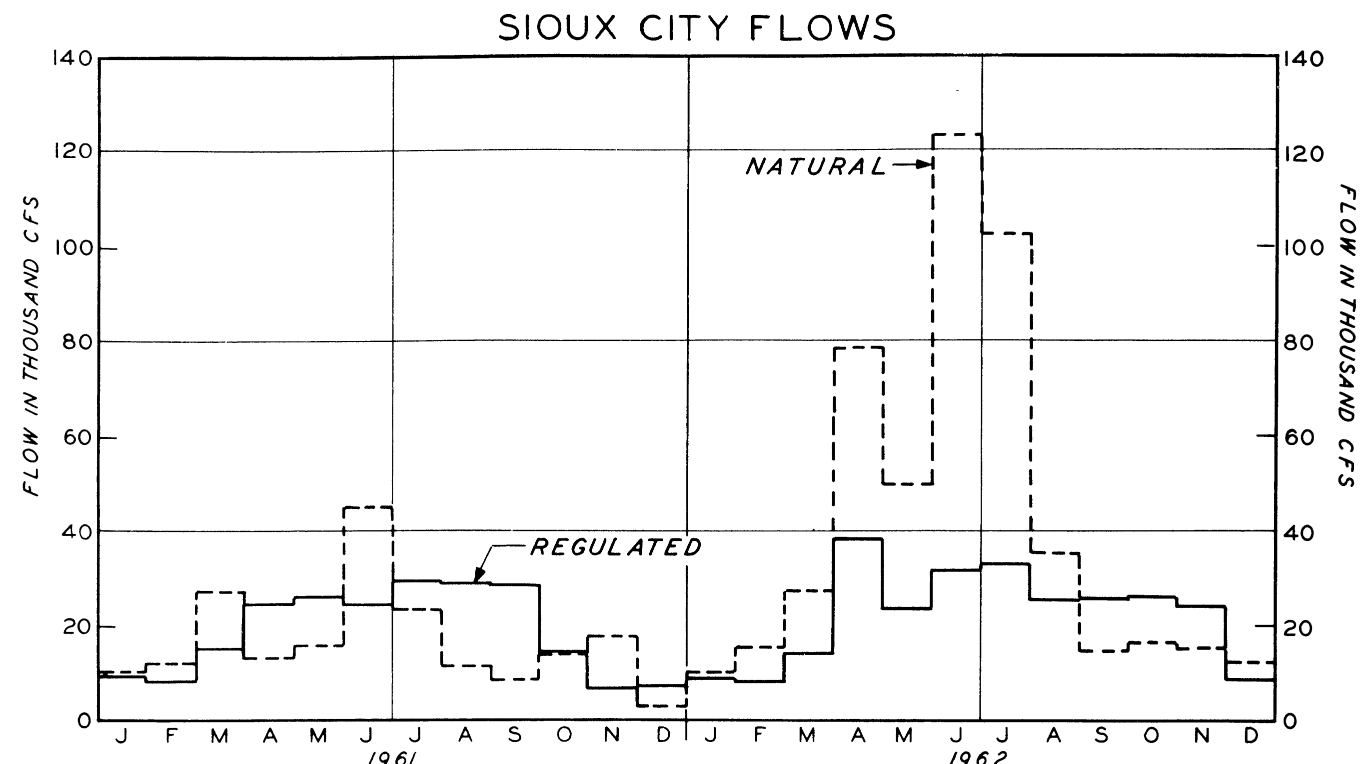
SIOUX CITY FLOWS
FLOW IN THOUSAND CFS
FLOW IN THOUSAND CFS
140
120
100
80
60
40
20
0
NATURAL
REGULATED
J F M A M J J A S O N D
J F M A M J J A S O N D
1961
1962

Figure 4

City would have experienced during these 2 years in the absence of the reservoir system. A reference to figure 2 will disclose that the interesting juxtaposition of these 12 and 30 million acre-feet years resulted in the greatest annual differential in yield to occur in the record to date.

Generation of electrical energy at Fort Randall and Gavins Point follows, perforce the release pattern. For somewhat over half the navigation season Oahe, the next upstream storage project, also follows this pattern of high releases, backing up the outflow from the downstream projects which contain relatively little conservation storage when compared to the nearly 39 million acre-feet shared by the three upstream reservoirs. (Big Bend which lies between Oahe and Fort Randall is essentially a run-of-river plant; its releases parallel those from Oahe except for some daily and weekly ponding.)

After Labor Day, Oahe releases are cut back and the drawdown of Fort Randall begins. By this means nearly 2 million acre-feet of conservation storage is evacuated from Fort Randall prior to the close of navigation. After that date, when Fort Randall releases are lowered to the 8,000 to 15,000 cubic feet per second, (depending upon storage and water supply) Oahe and Big Bend can operate throughout the winter with releases in the 15,000 to 22,000 cubic feet per second range, refilling the Fort Randall pool and generating additional winter power.

While this pattern of high summer releases and low winter releases still prevails in the lower part of the system, an opposite role is assigned to the upper portion. During the planning phase, channel capacity of the Missouri River under ice cover was set at 10,000 cubic feet per second below Fort Peck and 15,000 cubic feet per second below Garrison, for want of actual experience at higher flows.

Several years of repeated testing have now shown that the Missouri River channel below Fort Peck can safely carry 12,500 cubic feet per second under ice cover. At Garrison 30,000 cubic feet per second have been released without difficulty once the channel is solidly frozen in. These high levels of discharge and the associated high generation rate are utilized to offset the drop in energy which winter brings to the lower system. When navigation starts and the downstream projects begin their season of heavy generation, Fort Peck and Garrison are cut back to a level which avoids the generation of large amounts of very cheap dump power which once seemed a threat to the economic structure

of the projects. Figure 5 shows the interplay of these upper and lower components of the system and the extent to which, in toto, they enable system generation to conform to the pattern of the area load requirements. Even the load requirements themselves are changing in a manner which eases accomplishment of balanced operation. Although the peak load for the marketing area as a whole still falls in December, the growth of irrigation and air conditioning loads is being reflected in a steady increase in the July and August demand.

This is not to suggest that dump power will become a thing of the past. An unbalanced distribution of runoff into the system, such as was experienced in 1962 and again in 1965, places heavy pressures quite apart from the seasonal release pattern, to adjust storage at the possible price of some generation of dump power. The long-range prospect, however, with construction of the system near completion and firm power commitments approaching full development, is for a concurrence and not a conflict of interests between power and navigation.

The resolution of an important conflict between two primary functions of the system has not brought to an end all objection to the shape of things as they are, accompanied by pointed suggestions on how operations could be improved. Irrigators pumping directly from the channel are quick to react when a reduction in release cuts off their inlets behind newly forming sandbars, even though total flow in the river is several thousand times greater than the need. Increased discharges which might inundate pump motors are unequally unwelcome. Ferry operators call for more releases when their boats go aground or approach to access sites becomes difficult. Shippers have requested special consideration of an extension of navigation into the period of usual winter freezeup, and recreational interests call for both constant pool levels and constant discharges, while contractors building bridges and industrial plants submit detailed requests for control of stage and flow. These are earnest and well-meaning people who recognize a condition less than ideal in their locality or field of interest and also recognize how it might be corrected. Not so apparent to them is the consequence these corrective masures might have upon the intricate interrelationships of a system wherein power revenues alone average $90,000 a day and the value of stored water has been estimated at $2 an acre-foot. When one of these special requests can be accommodated without unduly burdening

MISSOURI RIVER MAIN STEM RESERVOIRS
GROSS AVERAGE MONTHLY POWER GENERATION
(AUGUST 1963 THROUGH JULY 1964)

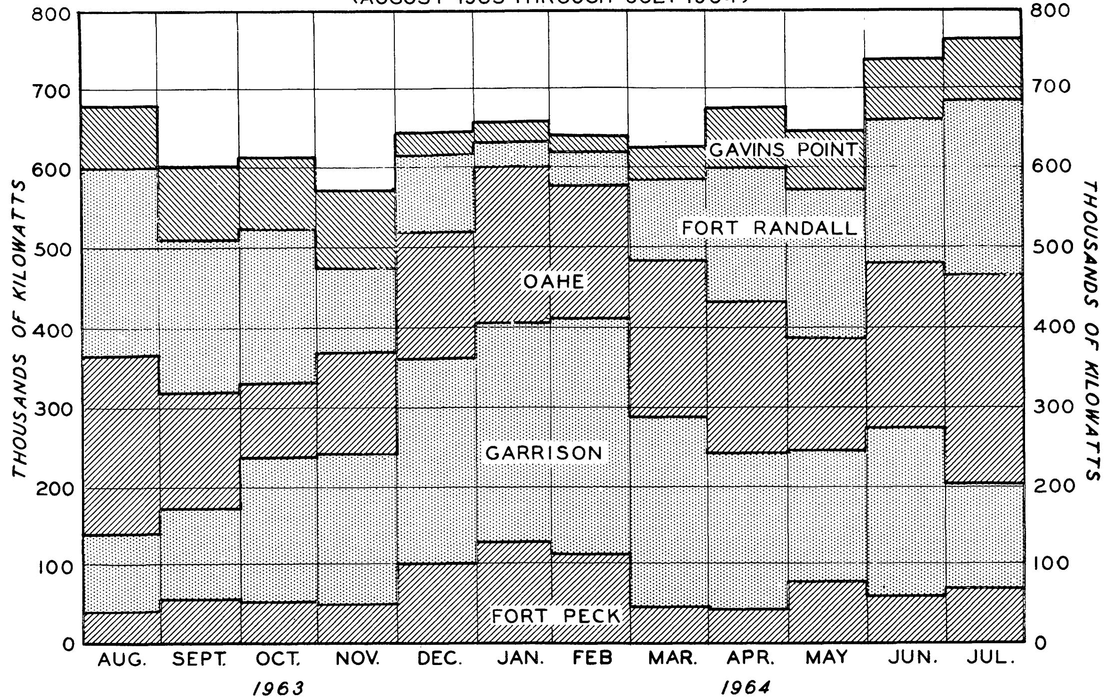

Figure 5

the primary functions, its scheduling and coordination are carried out by the Reservoir Control Center.

ACCOMPLISHMENTS OF THE SYSTEM

Three of the system's four primary functions have already begun the return of substantial benefits to the Missouri Basin and to the economy of the entire nation. Thel ikelihood of disastrous flooding on the main stem at or above Omaha has been almost completey eliminated and the threat to points downstream materially decreased. Flood damages averted by the main stem dams since Fort Peck began operation are estimated at $329 million. This does not include benefits allocated to the downstream levee works.

Power generation in fiscal year 1966 totaled over 9 billion kilowatt-hours. This is equal to the expected future long-term average. Power revenues during the operating year from August 1965 through July of 1966 were reported as $33 million.

The 1966 navigation season ended on December 1 when flows dropped below navigable rates at the mouth. Tonnage for the year amounted to 2,335,000 tons. Justification of the 732 mile navigation channel from Sioux City to the mouth was predicted upon the attainment of 5 million annual tons of commercial traffic 20 years after development of the entire channel to a depth of 9 feet. Although construction of the necessary control features will not be completed until the close of 1968, this movement of over 50 percent of the projected ultimate traffic by an uncompleted waterway augurs well for the finished project.

Major irrigation diversions have been late in materializing at the main stem projects but they appear to offer great potential for the future. Reauthorization of the Garrison Diversion Project was approved by the 89th Congress. This measure provides for initial diversion to place 250,000 acres under irrigation. Plans for the ultimate Garrison project contemplate irrigation of 1 million acres of dryland farms. The remaining major diversion proposed from the main stem is the Oahe project. As the modified plan currently stands, it would be a 495,000 acre unit. Construction and operation of these two projects would be a responsibility of the Bureau of Reclamation; their proposed depletion of the river has, however, been taken into account in all of the design and long-range operating studies conducted for the reservoir system by the Corps of Engineers.

No enumeration of the ways in which the reservoir system has affected its locale would be complete without a brief reference to recreation. In computing the benefit-cost ratio of the overall system, upon which justification of project features and payout of reimbursable cost is hinged, recreation was recognized only to the relatively minor extent of specific costs—the constructed cost of boat ramps, campsites and the like. This feature, however, has achieved a popular appeal second to no other. Visitor days spent at the six projects now total about 4.4 million a year and each visitor seems to take a proprietory interest in his particular project and its defense against regulation less than ideal for recreation. In addition, reaches of the river below the projects have been freed of much of their sediment load and assured of a more stable flow. As a result, an estimated half-million visitor-days are spent annually in this segment of the river.

POTENTIAL ADDITIONS TO THE SYSTEM

Below Yankton, S. Dak., site of the lowermost dam in the existing main stem system, the probability of further construction of major reservoirs on the Missouri River itself seems slight. The river valley is highly developed, with numerous industrial tracts interspersed among some of the highest-priced farmland in the United States. In addition to acquisition costs, the relocation of communications which would be disrupted along the hundred miles or more of a major reservoir make the economic status of such a project untenable for the foreseeable future. A number of tributary sites, however, do appear promising and are currently under investigation.

The most attractive prospect for future development lies to the north, above the upper reach of the present system. In the 200 miles of river between Great Falls, Mont., and the top of pool at Fort Peck are 550 feet of undeveloped head. Mean annual inflow to Fort Peck amounts to 7 million acre-feet. This combination of streamflow and head could support an optimum installation of 1.1 million kilowatts producing average annual energy generation of 2.4 billion kilowatt-hours. This would be an increase of over 50 percent in the installed capacity of the main stem system and 25 percent in average annual energy production. Moreover the additional regulation provided would augment flood control ability along the upper river while increasing conservation storage downstream. Substantial public interest—pro and con—

has been evoked by the possibility of developing this last remaining reach of the wild river; the favorable benefit-cost ratio makes further active consideration during the next several years appear certain.

CONCLUSIONS

The drainage basin of the Missouri River provided an exemplary setting in which to undertake a massive effort at comprehensive, region-wide regulation of water resources. Not only were the potential benefits high and their source diversified, but the very wilderness of the meandering river and the climatic extremes along its northern reach worked toward making a solution feasible. In few areas more favored by stable conditions of streamflow and precipitation would costs of lands and relocations in the river valley have permitted the construction of projects with a surface area of one and one-quarter million acres. Yet it is this magnitude which has provided the system with its operational flexibility, enabling it to provide service to four primary functions not noted for common and concurrent requirements.

Before construction of the system could be undertaken it was necessary that diverse interests throughout the wide area encompassed by the Missouri Basin be satisfied that multiple-purpose operation would work and that sufficient benefit would accrue to the several subareas to warrant their mutual support. Once the system was operational it became apparent that sustained and effective liasion with these varied interests was required to insure equitable conduct of the primary functions, and in addition, to offer the maximum recognition practicable to requests of a more specific and localized nature.

Compatibility of the primary functions has been arrived at through the exploitation of the system's high ratio of storage to runoff. By the device of regulation procedures which are offsetting or complementary in effect, delivery of service has in large measure been relieved of immediate dependence upon inflow conditions or the restrictions which may be imposed upon requirements for release from the system. For the future, additional development with a very attractive economic basis offers the possibility of increasing by half again, the system's ultimate installed capacity.

The integrated operation of the Missouri River main stem reservoir system, components of which are multiple-purpose proj-

ects in their own right, demonstrates the advantages to be obtained from such unity of purpose. No single project, operating alone, could be regulated to produce comparable achievements.

THE ROLE OF THE CORPS OF ENGINEERS IN ENVIRONMENTAL RESOURCES DEVELOPMENT

by

James D. Sears

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Man has never been satisfied to leave his geographical surroundings as he has found them. They must be changed or made "better" to serve a more "worthwhile" cause. Such endeavors usually result in a change in the environment. Because projects considered by the Corps of Engineers often result in environmental alterations, it is the responsibility of the planners to determine the effects and attempt, where possible, to mitigate any loss and maximize the benefit potential.

The primary purpose of any project is to develop the natural resources of an area in a manner that will be beneficial to a majority of the people, not only of the local area, but beyond. We must so develop these resources that not only our children, but our grandchildren will be able to chart a course for their future. The future with which we are concerned is predicated, not upon a scarcity of resources, but rather upon a multitude of choices.

Environmental changes are not always 100 percent acceptable to the population concerned. Recognition of the reasons for prevailing conditions is a necessity and objective consideration must be given proposed changes to bring about a balance, or harmony, between man and his environment.

Human occupation of the earth and the need to wrest a living from available resources is the primary factor resulting in environmental change. Generally, past development of the resources has been predicated on the "most economical solution." Housing is a typical example. The increased population has resulted in a need for additional housing. Most people shop for a house they can afford, not necessarily the house they would like to have. The housing developer, therefore, must meet the competition and in so doing

may create savings through the cost of sites, building material, and labor. Recognizing these economic facts, the next logical step would be to plan some means of satisfying public demand for reasonable cost and the building industry's demand for a reasonable profit. In addition, all persons involved have a responsibility to consider the overall harmonious environment as we understand it today and for the future. This can only be done through close coordination and cooperation between the environmental and physical planners. The results of either have a direct effect upon the work of the other. In fact, physical planning and social responsibilities are "married" and cannot be effectively "divorced."

Coordinated planning at this point seems to be the keyword. Because planning is done at many levels—private, city, county, State, and Federal—it is obvious that there are many points of view to be considered and many of these viewpoints are in conflict. Planning for the protection and development of our natural resources for the benefit and enjoyment of the people is a primary example. It is a field in which the U.S. Army Corps of Engineers long has been a leader, in coordination with the concerned individuals, and the political subdivisions of city, county, State, and Federal governments.

As the Nation's natural resources were developed, the emphasis shifted from single-purpose to multiple-purpose projects. This, plus the intricate interrelationship of the many resources involved and their uses, made it mandatory that all projects be given comprehensive study. These studies consider all aspects of land and water area developments over the physical or economic life of the project.

The construction of any large project changes the environment of the immediate suroundings. Therefore, it is imperative that, where possible, the fish and wildlife habitat be protected, and plans made to preserve the scenic, scientific, aesthetic, historical, and archeological resources. When preservation of these environmental resources is impossible it is necessary to actively plan for the inclusion of designs, construction materials, plantings, and facilities which will result in environmental beautification to make the project acceptable by the residents of the area.

Environmental resources planning by the Corps of Engineers enters the picture very early in all studies. Recreation is one such resource. No single item affects as many age groups, economic levels, or numbers of people as the development of the recreational resources.

In Army Engineers planning, recreation is considered a major function of all projects. It is given equal weight with flood control, navigation, water supply, irrigation, and power. Therefore, the recreation planner is asked during the feasibility study to determine the socioeconomic effect of the proposed project upon the recreation potential of the region. This increased emphasis upon recreation, raising it from a secondary feature to a primary function, is the logical result of the tremendous recreation use made of Corps reservoir projects by the public (168 million visits during 1965).

Although normally the public considers that reservoirs constitute the main recreation areas under the jurisdiction of the construction agencies of the Federal government, recent field studies have indicated that there is rather heavy recreation use of levees, jetties, and breakwaters. This aspect of recreation use was recognized in June 1962 when the Flood Control Act was amended to make recreation authority, provided for reservoirs, applicable to nonreservoir projects such as harbors, canals, and other waterways, and local flood protection projects. This provision is found in section 207 of the 1962 Act. It permits consideration of Federal cost sharing of land acquisition for public access if the recreation benefits are of regional or statewide nature. Local agencies are responsible for providing lands and rights-of-way for the other purposes for which the project was authorized.

In reaches of the stream where more land is not needed, it is possible, up to 3 percent of project costs, to include imaginative construction methods, materials, and landscaping which add beauty to the basic structures. It is recognized that the environment within which a structure is located has a great deal to do with the acceptance of the project by the local residents. It is important that the project provide the neighborhod in which it is located with a landscaped space compatible with the surrounding area.

The Corps of Engineers is presently applying these criteria to all water control projects being studied—both reservoir and nonreservoir. It should be noted that any recreation facility or activity must be in conjunction with, and compatible to, structures necessary for successful functioning of other project purposes.

Planning the best use of the environmental resources for presentation to the public and for the Preliminary Master Plan requires knowledge of a varied number of disciplines: (1) Demography is necessary to determine the future population and its composition in the area affected by the proposed project; (2) socio-

logical information is necessary to determine the future use of leisure time (this touches on automation and cybernetics); (3) an economic study is necessary to determine the costs and benefits of the proposals; (4) an ecological study is necessary to determine the impact of the project and the resultant human use on the fauna and flora; (5) real estate information is required for the acquisition of sufficient land to satisfy futuren eeds; (6) the requirements of a landscape architect must be considered; (7) the responsibilities of an engineer are vital; (8) an architect must develop plans which adapt the selected facilities to the existing terrain and vegetative conditions in order that the inherent beauty of the area is not lost through misuse or overuse; (9) fish and wildlife conservation is of great importance; (10) when applicable, forestry practices must be considered; and (11) to round out the picture, history and archeology features must be incorporated.

In applying all of these disciplines, Army Engineers also must consider the overall size of the recreation area involved. In a sense the problem is very similar to that encountered by a farmer in planning pastureland needs for his beef herd. If the farmer turns 10 head of cattle into a specific pasture, they can all gain weight; 12 head may hold their own weight, but 15 head in the same pasture results in a loss of weight per head, plus overgrazing of forage, introduction of weeds and possible erosion of soil.

Without careful planning and management, recreation areas will also deteriorate and required a high annual rehabilitation appropriation. The Corps of Engineers nor any other land management agency wants to establish potential recreation slums. The desire is to retain intact the inherent beauty of all project areas. These are built for and by the people, and they should be able to obtain full enjoyment from a visit to such an area. Therefore, in addition to being visually attractive, they also must be practicable.

All of the items mentioned in this article are explained in more detail in Master Plan prepared for each project. This presents an inventory of usuable recreation areas or site surveys. After locating and studying potential sites, a determination is made of the type of use which will be assigned to each site. Typical of such uses are boat launching facilities that require certain slopes; overlook areas that have broad vistas; camp grounds which require gentle slopes; swimming areas that require safe conditions; and fishing areas that can, if possible, be shielded from water skiers. By applying standard development factors to each site it is possible to determine the carrying capacity, After all sites have been

evaluated and assigned uses, the next step is to establish a priority of development dependent upon anticipated use.

Each site must be considered separately to determine the limitations of desirable use in order to plan for the required facilities. Through the proper location of improvement, overcrowding and loss of privacy can be prevented. Other limiting factors include availability for parking spaces, number of campsites, and picnic units.

For determining the number of people, by activity, who can use a particular site of known acreage, the following formula was developed by the San Francisco District.

$$\frac{A \cdot U \cdot P \cdot S \cdot T}{C} = RD$$

A = acres of land
U = units per acre, including buffer zone
P = size of average party
S = season, length in days
T = turnover, number of times unit is used each day
C = actual annual use of capacity (normally ½)
RD = recreation days per year

In instances where the annual anticipated use has been determined and it is necessary to determine the number of facilities necessary for the "Design Day" (recreation use on the average weekend day during the normal recreation season), the following formula is useful.

$$\frac{U \cdot X \cdot W}{N \cdot P \cdot T} = F$$

U = annual use
X = percent of use for activity
W = percent of use on weekend day
N = number of weekends during normal recreation season
P = size of average party
T = turnover, number of times unit is used each day
F = facilities (number of units)

After the Recreation Master Plan has been approved, Engineering Design Memoranda are prepared. This is another area where cooperative agreement is vital. It is at this period that the recreation planner comes up against the cold hard facts of life in the shape of a design engineer. He must be able to present, in a staff

meeting, sufficient arguments for recreational plans to overcome the objections raised. For example, justification is necessary when it costs more to put in an exposed aggregate walk over a concrete walk, or a picnic table constructed of 3 inch material against 2 inch stock, a rock wall instead of a poured concrete wall or planter box around a building instead of paving up to the wall. Once the Recreation Master Plan and the Engineering Design Memoranda are in agreement, construction can begin.

During construction of the facilities a member of the recreation planning staff is assigned to the construction site to be there if field changes are needed. It may be found that the proposed road alignment cuts through a grove of trees, and a slight realignment will preserve this natural feature. Or perhaps a better setting can be provided by shifting a picnic or camp unit 5 feet.

Planning is slightly different for recreation facilities to be constructed along streams modified by flood control works. After determining the eligibility of development under existing policies, procedures for estimating use and the evaluation of recreation potential are similar to those above. Normally, there remains very few natural areas adjacent to a channel project after construction so special consideration must be given to designing recreation facilities within thel imitations presented. It is sometimes possible without interfering with functions of the project to establish strip parks, walks, and trails along or adjacent to levees, or to construct boat launching ramps. This has been done by the Corps on the Sacramento River and there are plans to do so on the Napa River.

Where excess excavation is part of a project, judicious placement of such excess material might provide an expanse of land level with the top of levees that could give a view of the stream. Landscaping would make this an attractive picnic or camp area.

Most levee systems need a ponding area on the landside of the levee where local runoff is stored during a flood while the normal outlet, being under water, is closed. In most instances the land is flooded only during storms and remains dry or marshy during the balance of the year. Since these areas usually are purchased as a part of the flood control project, they can serve a dual use. One example is a proposal being considered by the local people along Alameda Creek near Oakland, Calif. An authorized flood control project will provide flood protection by levees. Behind the levees is a ponding area. By excavating portions and building up other sections provisions can be made for a permanent lake with islands and other high land. In this way accomodations can be made for

picnicking, swimming, and hiking. The East Bay Regional Park District is preparing the plans and coordinating with the Corps of Engineers.

The city of Napa is another instance where there are plans for dual use of a ponding area. In this case, the pond is in the proposed golf course and by proper land shaping it will be possible to accommodate the flooding and also provide water traps.

The definition of a recreation site is an area of land suitable for or developed for a specific recreation use or closely related uses. Or it is a specific site in a large recreation area. The development of recreation site plans is really the key to the successful development of a recreation area. Recreation site plans generally show the specific location and general design of all roads, parking, plantings, trails, walks, improvements, structures, and utilities. They provide for proper utilization of the site, control of vehicular and pedestrian traffic, distribution of use, means of sanitation, protection of public safety, details of fireproofing and for landscaping. Site planning is the arrangement of improvements in such a manner that the quality and atmosphere of the natural environment will be preserved for the enjoyment of the users.

Each site possesses at least one important natural feature which will be recognized and given special consideration in planning. Such a feature does not have to be outstanding or unique, but it will be the most important. Typical examples are lakes, ponds, streams, meadows, rock outcroppings, grassy swales, groves of trees, or views. Roads and other improvements will be planned, located, and designed to protect such natural features and to enhance public enjoyment. Natural features normally control the location and design of the improvements. Roads and other facilities are to be located around, or away from, natural features rather than crossing or meandering through them. Usually a space of 50 feet is sufficient for a buffer zone between roads and other improvements or the natural feature.

Improvements on recreation sites generally are located and designed to serve their intended function and at the same time be as inconspicuous as possible. The purpose, of course, is to retain public awareness of the natural. Where facilities are obvious, consideration is given to the use of materials, shapes, or colors that are pleasing to the eye and not a visual intrusion.

Existing vegetative cover is protected from misuse or overuse. Site plans indicate location and design of improvements necessary for vegetative cover protection. Acceptable improvements for this

purpose are: Barriers or curbs which control vehicular traffic; limitation of parking spaces; broad and direct surfaced walks to encourage mass pedestrian use; and systematic seeding, fertilization, irrigation, and planting where necessary to rehabilitate deteriorating vegetative cover.

Road systems within recreation sites are planned or adjusted to fit natural conditions. When the road system is well planned, other developments usually are in keeping with the natural features. Examples of this relationship are—

(*a*) Where recreation sites are in narrow valleys or canyons, roads are often at the toe of the steep slopes to permit the greatest possible public use of gentle bottom lands.

(*b*) Ridge roads are best located along the nonview side if the ridge is narrow and there is a good view from only one side; or roads may be located down the crest of the ridge if the ridge is wide and has a good view from both sides.

(*c*) It is preferable that roads have a gently curving alignment, undulating at ground level. Cuts and fills are reduced to the absolute minimum. Long straight roads seldom serve recreation objectives.

(*d*) In some instances, roads are located to control use and protect the natural features. For example, near lakes and streams roads located 50 to 100 feet from the water's edge provide a barrier to occupancy immediately adjacent to the water's edge. This strip should be free from improvements and available to all visitors.

Progress of our dynamic society often indicates that some changes are necessary. These changes, of necessity, will at times alter the environment. Therefore, it is most important not to dwell on that which is lost or altered, but rather to consider the many possibilities resulting from the changes. This does not imply that change automatically requires someone to "give in" on project development. Instead an aggressive attitude of cooperation must be assumed in order to seek the incorporation of items beneficial to the public.

Plans are not limited to the old "tried and true" concepts of acceptability. If as many technological advances are made in the next 50 years as have accrued in the past, many living patterns may be common that are not conceivable today. Planners, should make plans not only when necessitated by change, but also for purposes of planning for change. Planners will have to be aggressive, and adaptable.

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